GENERAL

INTENT

The guidelines within this Section generally apply to all new construction (including entire new buildings as well as remodels or additions to existing buildings) at Lawrence Berkeley National Laboratory (LBNL). Questions as to application or modification of these guidelines shall be directed to the University's Representative for clarification and acceptance.

Additional and/or specific mandatory design requirements are noted within the Project Design Requirements (PDR), however, the University will consider equivalent design solutions providing they satisfy the programmatic requirements in a more functional or cost effective manner and are in compliance with the design requirements set forward in the Construction Details and Design Guidelines (CDDG).

1. ARCHITECTURAL DESIGN REQUIREMENTS

The following are general requirements for architectural design.

A. Code Analysis: The title sheet shall contain a Code Analysis which includes:

1. Type of Construction.
2. Occupancy Classification.
3. Rated assemblies and how they are achieved.
4. Exit path and egress path.
5. The design shall comply with the most restrictive of applicable codes.
6. All new work shall comply with disabled accessibility requirements in accordance with the Americans with Disabilities Act (ADA). Exception: Laboratory benches, fixtures, and fume hoods are exempted. LBNL provides accessibility for laboratory benches, fixtures, and fume hoods on as needed, case-by-case basis.
7. LBNL requires two (2) exits from B-Occupancy laboratories over 500 SF.

B. Conceptual Design: When provided and included in the PDR, forms the basis of the design development phase.

1. The conceptual design of the project has been validated by the user/client and approved by the University for advancement to the next stage of design.
2. The Architect/Engineer (RDP) shall review the conceptual design and verify its assumptions. The University will consider alternate design concepts if the alternate solutions will satisfy the programmatic requirements in a more functional or cost effective manner.

C. Modifications to existing buildings shall be compatible with the overall character of existing buildings in construction and finishes.

D. All exposed new elements including piping and wiring shall be painted unless prohibited by code. Colors shall match existing or be selected from the LBNL Interior Finish and Color Standards per the LBNL Master Specifications.

E. Wherever possible, offices, conference rooms, and general use administrative areas shall have operable windows.

F. Exterior glazing shall be low emissivity (low-e) clear glass with a maximum Solar Heat Gain Coefficient (SHGC) of 0.27, maximum Visible Light Transmittance (VLT) of 64%, and minimum Light to Solar Gain (LSG) ratio of 2.37. Dark tinted glass and reflective glass are not permitted on the LBNL site. Reflective glass is defined as being more reflective than 15% visible light reflectance from the exterior surface of the glass.

G. LBNL standard for roofing color is a minimum initial Solar Reflectance Index (SRI) of 78 for low-sloped roofs (pitch less than or equal to 2:12) and minimum initial SRI of 29 for steep-sloped roofs (pitch greater than 2:12).

H. Auditoriums, Meeting Rooms, Private Offices

The walls separating the auditoriums, meeting rooms, and private offices from the common areas of the building shall be full height up to the bottom of the floor above. All walls surrounding these rooms shall be acoustically designed and treated. The walls shall be caulked airtight using specified acoustical or fire proofing caulk.

I. Electrical Rooms and Communication Closets

The RDP shall provide dedicated electrical rooms and communications rooms/closets. The RDP shall coordinate with the project electrical engineer on the size and layout of electrical rooms and communication closets. Electrical rooms shall be sized to include all designated electrical power distribution equipment, fire alarm panels, transformers, switchboard, panels, etc., with all the code required entries/exits, and clearances for equipment operation, maintenance, and removal.

Communication rooms/closets shall be sized to include equipment for telephone, card access, and CCTV security, and public address systems with code-required clearances for maintenance and space provision for future additions.

The electrical rooms and communication rooms/closets shall be separate dedicated rooms and shall not be located in janitorial closets or storage rooms. Door swings shall comply with the latest version of the National Electrical Code (NEC).

J. Waste Stations

The Architect shall provide adequate space for compost, recycling, and landfill waste stations and shall coordinate size and location of waste stations with Sustainable Berkeley Lab.

K. Planned Flexibility

1. Electrical distribution, lighting, security, fire protection, HVAC, and voice/data cabling lines shall be located and routed in a logical manner to provide an infrastructure that facilitates reconfiguration of the individual spaces.
2. Utility drops shall be organized and distributed in perimeter locations compatible and appropriate to room functions for ease of modification.
3. Built-in features shall be modular and configured so that they do not become obstacles to partitioning and/or reorganization of the space.

L. Laboratory Furniture & Casework

Refer to the “LBNL Design Guidelines for Laboratory Furniture” on the Facilities website (http://facilities.lbl.gov/). These guidelines apply to laboratory casework (bench tops, shelves, and under counter storage), computer carrels, and stools.

M. Human Factors

1. Buildings shall be designed with awareness and sensitivity for human interaction with the built environment. The RDP shall consider scale, way-finding, and adequate clearances.
2. Stationary workstations in the office/laboratory setting shall provide adequate surfaces for ergonomic arrangement of the computer keyboard, pointing device, monitor, and document/work holders. Follow good ergonomic principles providing height adjustable work surfaces, openings adequate for leg and knee clearances, and sufficient overhead space to allow adjustments to vertical equipment placement. In particular, care shall be given when designing fixed workstations for high intensity repetitive activities, such as data entry, pipetting, and microscope use. Workstations where extended period computer work occurs shall be at least 36 inches wide and adjustable for either seated or standing work. The BSR/HFES100 Draft Standard for Trial Use, “Human Factors Engineering of Computer Workstations” or ANSI/HFS100-1988 “American National Standard for Human Factors Engineering of Visual Display Terminal Workstations” shall be followed to the extent practicable by the RDP.

N. Acoustics

1. All hydronic, roof drains and other plumbing penetrations (toilet rooms, hydronic, etc.) in walls shall be caulked airtight using specified acoustical or fire proofing caulk.
2. Where recessed fixtures of any type are installed (e.g., fire extinguishers, electric distribution panels, recessed water fountain, recessed bookcases, etc.), ensure that required acoustic wall construction extends behind these recessed elements.
3. Installation of noisemaking equipment (such as telephones, water fountains, etc.) is not allowed on walls of rooms requiring a specified level of acoustic isolation.
4. Use surface mounted rather than recessed lighting fixtures and fans, etc., at ceilings of rooms requiring acoustical isolation in order to minimize sound transfer.
5. Space doors to rooms requiring acoustical isolation so that neighboring rooms do not have directly adjoining doors, and so that doors on opposite sides of corridors do not directly face each other. Stagger all doors. Do not place any doors to rooms requiring acoustical isolation opposite stairwell or toilet room doors.
6. Provide a maximum gap of 1/2-inch at all door bottoms (less when possible) unless a larger gap is required as an air path for make-up or transfer air. Toilet rooms not located on circulation corridors shall have automatic door bottoms.
7. Separate studs, with a structural, in-wall air gap, shall isolate the jamb of all heavily used corridor doors from any adjacent rooms requiring acoustical isolation.
8. Mechanical equipment in spaces above or below rooms requiring acoustic isolation shall be physically isolated, including piping and conduits, from walls, floors, and ceilings.

O. Custodial Spaces

1. Custodial Equipment Rooms shall be strategically located on all floors throughout the building for the storage of custodial cleaning equipment. Locate to avoid moving equipment long distances. Minimum size: 55 sq. ft. Provide one (1) room per 20,000 gross sq. ft. Typical equipment and sizes are:
   a. Mopping cart: 2 feet by 6 feet.
   b. Trash cart (6 bushel): 2 feet by 3 feet.
   c. Vacuum, carpet (upright): 3 feet by 1 foot.
2. Custodial Wet Closets shall be strategically located on all floors throughout the building; they may be designed in conjunction with Custodial Equipment Rooms and shall contain the following (minimum size: 60 sq. ft.):
   a. 32-inch by 32-inch or 30-inch by 24-inch floor basin with approximately 4-inch curb height.
   b. Hot and cold water outlet with attached hose (and wall clip) for filling buckets, etc.
   c. Rack with three (3) or more dry mop and dust mop hooks or clips on wall away from basin.
   d. Rack with three (3) or more wet mop hooks or clips arranged to permit dripping of wet mops into basin.
   e. Pad/brush holder.
   f. Step ladder: 1 foot by 2 feet.
   g. Vacuum, wet or dry: 2 feet by 3 feet.

h. Shelving: 1 foot deep by at least 15 lineal feet of adjustable shelving.

i. Electric GFCI receptacle, located at 16 inches above finished floor and near the corridor door.

3. Custodial Storage Rooms shall be one (1) room per building for bulk storage of custodial supplies, may require limited shelving, and shall be near the loading dock and an elevator. Minimum size: 100 sq. ft.

4. Additional requirements for custodial spaces are as follows:

a. Doors shall swing out and shall be large enough to permit free movement of boxes and equipment.

b. Custodial Wet Closets shall have exposed concrete or painted drywall ceiling, hardened smooth concrete floor, and washable hard smooth finish on concrete block walls. Provide glazed tile walls at basin.

c. Finishes in other custodial spaces shall be similar to those for Custodial Wet Closets.

d. Provide adequate ventilation.

e. Lighting shall meet Illuminating Engineering Society of North America (IES) guidelines with no exposed lamps. No custodial rooms shall contain telephone switchgear, elevator panels, electrical panels, metering devices, or similar equipment.

P. Safety Restraints

1. All open shelves shall have a 1-inch high lip or an applied device such as a bar that restrains objects on the shelf in the event of an earthquake.

Q. Door Hardware

1. All hardware shall be bright chrome (US26).

2. All door handles shall be lever design. Schlage “Spartz”.

3. All exit devices shall be Von Duprin 98 series.

4. All keying shall be coordinated with LBNL Protective Services Lock Shop.

R. Toilet Accessories per the LBNL Master Specifications.

S. Furnishings per the LBNL Master Specifications.

1. Furniture to be coordinated with LBNL Facilities Division Furniture Procurement Program.

T. Drawings

1. A comprehensive and coordinated reflected ceiling plan shall be developed to integrate all ceiling mounted elements (e.g., lighting fixtures, air supply/return grilles, sprinklers, smoke detectors, high sensitivity smoke detectors, speakers, occupancy sensors, ceiling fans, etc.) to suit the requirements of all scheduled activities. The ceiling plan shall indicate the equipment maintenance envelope.

2. A comprehensive and coordinated vertical section shall be developed to integrate all building utilities, structural components, finish systems, casework, furred spaces, and special system components. This is essential in areas with a high density of building utility components such as laboratories, central corridors, service rooms, and equipment rooms.

3. Provide details showing flashing and waterproofing systems for all exterior envelope penetrations.

U. Specifications

LBNL will provide the LBNL Master Specification sections for incorporation into the construction documents. The RDP shall select specification sections that are appropriate for the project, review the sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Architectural design elements are covered under the following specification divisions:

Division 06	Wood, Plastics, and Composites
Division 07	Thermal and Moisture Protection
Division 08	Openings
Division 09	Finishes
Division 10	Specialties
Division 12	Furnishings

V. Registered Design Professional (RDP) Responsibilities

LBNL will provide the LBNL Master Specification sections for incorporation into the construction documents. The RDP shall select specification sections that are appropriate for the project, review the sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

2. GENERAL CIVIL DESIGN REQUIREMENTS

The following are general requirements for civil design.

A. Storm Drainage

During construction, if relocation of existing storm drainage facilities is required, careful measures shall be taken to provide controlled diversion of storm water until the system is again intact. Temporary silt traps, sedimentation ponds, and/or diversion structures shall be designed and included in the construction documents to minimize erosion and siltation during construction in accordance with the Facilities Storm Water Pollution Prevention Plan.

B. Foundation and Retaining Wall Drainage

All foundation and retaining wall drainage shall be in accordance with the recommendations of the Geotechnical Engineer. At a minimum, all earth retaining walls shall have a back drain consisting of drain rock wrapped in filter fabric with a perforated PVC pipe draining to daylight or an existing storm drainage facility.

C. Earthwork

Compaction shall be required to achieve a minimum of 95% of maximum density at optimum moisture content +1%/-3% beneath roads and paved areas, and a minimum of 90% of maximum density at optimum moisture content +1%/-3% in all other areas unless otherwise recommended by the Geotechnical Engineer. Overexcavated areas under foundations shall be filled with lean concrete or Controlled Density Fill.

D. Excavated Materials

Excavated soil and other materials shall comply with construction waste diversion requirements from LBNL's Sustainability Standards for New Construction.

E. Surveys

On the LBNL Berkeley main site, local survey reference points shall be established by the University for both horizontal and vertical control. Limited topographical maps of the site shall be provided by the University. The RDP shall be responsible for requesting additional surveys necessary to assure proper design and accurate estimating of construction quantities.

Land surveys for projects on other sites shall be the RDP's responsibility.

F. Geotechnical

For projects on the LBNL Berkeley main site where geotechnical information is available, it shall be reviewed by the RDP to determine if sufficient information exists to design the facility, with the exception of retaining walls that shall support more than 6 feet of soil and any site where the potential for liquefaction exists. In these cases a geotechnical investigation is required by the California Building Code (CBC). In other cases, if the RDP determines that additional or supplemental information is required, the RDP should notify LBNL who will retain a Geotechnical Engineer to conduct a geotechnical investigation for the project and provide all required geotechnical information. It shall be the responsibility of the RDP to

review, interpret, and incorporate the geotechnical information and recommendations into the design and construction documents.

Geotechnical investigations for projects on other sites shall be the RDP's responsibility.

G. Roadways

All removed pavement shall be replaced in kind or as recommended by the Geotechnical Engineer. Pavement construction shall be flexible type based on a traffic index of 5.5 for automobile areas and 8.0 for truck areas and subgrade "R" value as recommended by the Geotechnical Engineer.

H. Drawings & Calculations

The RDP shall prepare civil drawings required to accurately define and describe all construction work necessary to provide a finished product as outlined in these Construction Details and Design Guidelines. Cross-sections shall be the same scale for both horizontal and vertical dimensions. Design calculations shall be performed in English units and the appropriate sizes shall be converted to English units. Each page of the calculations shall be initialed by the engineer responsible for performing the calculation as well as the engineer responsible for checking. Drawings and specifications shall be in English units. Design effort shall be made to equalize the landfill and cuts of the construction site to minimize import or export of soil.

I. Specifications

LBNL will provide the LBNL Master Specification sections for incorporation into the construction documents. The RDP shall select specification sections that are appropriate for the project, review the sections, edit them to suit the project, and submit a "track changes" copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Civil design elements are covered under the following specification divisions:

Division 02	Existing Conditions (if required)
Division 31	Earthwork
Division 32	Exterior Improvements
Division 33	Utilities

3. LANDSCAPE REQUIREMENTS

The following are general requirements for landscape design. Refer to the LBNL Master Specifications for more detailed information.

A. General Design

1. All design shall be in compliance with the LBNL Design Guidelines referenced by the Long Range Development Plan.
2. Landscape areas shall contribute to the identity of each building complex. New landscaping at existing buildings shall conform to or complement the existing character of planting.
3. The design of each building complex shall be sensitive to, and complementary of, any existing sensitive vegetation and mature specimen trees. All landscaping shall endeavor to enhance the natural beauty of the site and to establish or preserve the identity of each building complex.
4. The landscape design shall provide for bicycle parking and circulation as well as for pedestrian circulation.

B. General Planting Selection

1. Planting areas within building compounds shall respond to the uses and functions of the buildings and spaces: providing shady and sunny seating areas, colorful entries, and screening or buffers when necessary.
2. Plant sizes shall be chosen to assure long-term adaptability to specific site locations.
3. Coordinate proposed plant material with Facilities Operations Department Groundskeeping Group.
4. In order to reduce the potential for accidents, plant sizes shall not inhibit a clear line of vision for pedestrians and vehicle operators.

C. Drainage

1. Ponding of water on the site ground surfaces is not allowable; all surfaces shall have a positive drainage.
2. Drain all water away from the building foundations.

D. Maintenance

1. Plant materials shall be selected for ease of maintenance so as not to require substantial pruning, leaf and litter collection, or pest control.
2. Avoid large deciduous trees in interior courtyards that require substantial leaf collection.
3. Plants shall be drought tolerant and low water use types, capable of thriving without ongoing, automated irrigation following an initial period of up to 18-months to establish new landscaping.

E. Lawn Areas

Lawn areas shall be avoided

F. Design Considerations for Existing Trees

All trees on LBNL site are a prime natural asset and shall be carefully protected. All new construction shall observe the following guidelines:

1. Whenever possible, avoid fill or excavations within the drip line of trees, to avoid suffocation and root cutting. Avoid placing utility lines through trees to be saved.
2. Establish finish grades on paving, footings, etc., above the root system. The grade at the base of all trees shall not be raised or lowered.
3. Limit root coverage to not more than 40 percent unless a loose permeable covering is used such as gravel, decomposed granite, etc.
4. Re-establish drainage systems around trees where natural drainage systems have been disturbed. Finish grades shall drain away from the trees.
5. If established trees shall be removed, replacement with 48-inch box specimens shall be provided for in the design for each tree removed.

4. PARKING/CIRCULATION REQUIREMENTS

The following are general requirements for design of parking and circulation.

A. General Design

1. Parking shall be located at sites identified in the LBNL Long Range Development Plan.
2. All parking areas near buildings on site shall include a portion of the total spaces for handicapped parking as per CBC requirements.
3. Pedestrian movement in and out of parking areas shall be incorporated into the landscape design.
4. Parking shall not create an obstacle for pedestrians traveling from one building to another.
5. Parking and service areas shall be landscaped, retain existing trees where possible, conform to the topography, and be limited in size to decrease their visual impact.
6. All parking areas or clusters of areas one (1) acre or larger shall either be provided with sedimentation/infiltration basins designed to capture the majority of suspended or emulsified contaminants or they shall be provided with easily maintainable grease traps.

B. Minimum Parking Area Requirements

1. Provide wheel stops (curb may be used as a wheel stop).
2. Provide wide striping (with traffic paint) at all Handicapped (HC) parking spaces.
3. Provide minimum dimensions of 8 feet-6 inches wide by 18 feet-0 inches long per space.
4. Motorcycle parking shall be provided as specified in the Project Design Requirements (PDR).
5. Provide bicycle parking convenient to building entries and on the project site. Verify amount of bicycle parking with PDR requirements.
6. Provide Lighting for all parking areas. The light intensity shall be per Electrical Requirements.

C. Vehicle/Bicycle/Pedestrian Circulation

1. Two-lane roads shall be 24 feet wide, minimum, with minimum 30 feet radius at curves.
2. All roadways shall have concrete curbs or an asphalt concrete (AC) berm for establishing the edge of pavement and directing runoff.
3. Provide asphalt or concrete site paths of a width appropriate to its intended use. If asphalt is used, provide pressure treated pathway headers. Verify with the University's Representative.
4. Provide for bicycle circulation from bike paths to bike parking and from pedestrian path to building entry. Bicycle and pedestrian paths shall be separate when possible.
5. Provide continuation of existing pedestrian walkways along roads (sidewalks) and as needed to maintain existing routes of pedestrian travel.
6. Provide lighting for roadways and bicycle and pedestrian pathways as specified in the PDR. The illumination levels shall be per the Electrical Requirements and the PDR.

5. GENERAL STRUCTURAL REQUIREMENTS

Building floor and roof loads shall be designed to exceed code minimums. Verify with the University's Representative for specific design criteria.

A. General

1. Structural design shall account for all loads to which earth retaining systems and the building structure may be subjected including dead, live, wind, seismic, etc. When live loads are not defined in this document, they will be reviewed and approved by the LBNL Structural Engineer prior to the start of Preliminary Design.
2. Foundation design shall be in accordance with the recommendations of the Geotechnical Engineer. See "Geotechnical" in the Civil Criteria. The RDP shall be responsible for the interpretation of the geotechnical information and for incorporation of the Geotechnical Engineer's recommendations into the design and construction documents.
3. Items that shall be embedded in structural concrete shall be dimensionally located on the structural drawings regardless of the discipline responsible for designing them. The location of all embedded items shall be reviewed and approved by the Structural Engineer. The RDP shall consider the use of UL listed pipe hangers for elevated concrete slabs on metal deck and shall coordinate their use by the mechanical and electrical disciplines.
4. Conditions requiring temporary shoring of embankments and existing facilities shall be clearly described in the construction subcontract documents along with any minimum design criteria. The specifications shall require all subcontractor shoring design of embankments to be performed by a Civil Engineer who is registered to practice civil engineering in California, and all subcontractor shoring design for structures to be performed by a Structural Engineer who is registered to practice structural engineering in California.

B. Specific Loading

1. Roofs shall be designed for a minimum mechanical equipment load of 50 lb./sq. ft. or the actual weight of the mechanical equipment, whichever is greater.

C. Lateral Force Design Criteria

1. All structures and buildings and their components, including non-structural components and equipment, shall be designed to the requirements of "Lateral Force Design Criteria," RD3.22, of the LBNL CDDG, Volume 4 - RDs, unless otherwise specified. The Occupancy Importance Factor (I), shall be determined from the requirements listed in the edition of ASCE-7, "Minimum Design Loads for Buildings and Other Structures", that is in effect.
2. All building elements of buildings and structures shall be designed to withstand the minimum horizontal and uplift wind pressures set forth in "Lateral Force Design Criteria," RD3.22, of the LBNL CDDG, Volume 4 - RDs.
3. All roads, parking lots, foundations, earth-retaining structures, and other earthworks shall be designed in accordance with the recommendations of the Geotechnical Engineer.

D. Design Documents

1. At the onset of the project, a site visit by the Structural Engineer of Record (SER) is mandatory to review the existing conditions and archival records for any existing structure that shall be modified by the project. The archival records may be copied by the SER using LBNL facilities.
2. The RDP shall submit for University review, at Design Development phase and at 50% and 100% Construction Document phase, the design calculations (including any finite element model analyses) for all structural portions of the project. The calculations can be submitted either as hard copies or electronically in PDF format, or both. At 100% Construction Document, the RDP shall furnish an electronic copy of the finite element model(s) of the project, in SAP 2000 format or in “DXF” format at a minimum. The RDP's schedule shall allow a minimum of two (2) weeks for each review. Design calculations shall be performed in English units. Drawings and specifications shall be in English units.

E. Design Calculations

1. Structural calculations pertaining to a building and all appurtenances within or attached to the building shall be sealed by a Structural Engineer registered in California. Structural calculation of elements separate from a building (e.g., retaining walls, trenches, and exterior equipment pads) may be sealed by a Civil or Structural Engineer registered in California. Each page of the calculations shall be initialed by the engineer responsible for performing the calculation as well as the engineer responsible for checking.
2. Calculations, stress diagrams, and other pertinent data shall accompany the plans and specifications and shall be legible and sufficiently complete so that calculations for individual structural members, equipment, etc., can be readily interpreted. The computations shall be prefaced by a statement clearly and concisely outlining the basis for the design. Calculations produced with computer software shall display all formulas as well as results. Structural calculations shall indicate the manner in which the building, non-structural components, and equipment shall resist vertical loads and horizontal forces. The computations shall be sufficiently complete to establish that the structure shall resist the loads and forces prescribed in the design program and references, including all non-structural components and equipment. Assumed safe allowable soil loadings and specified strengths of concrete shall be given in computations and noted on plans. Where unusual conditions occur, such additional data as are pertinent to the work shall be submitted. Aside from the primary goal of establishing an engineering basis for the information shown on the drawings, the calculations shall be organized and annotated so that an independent engineer is consistently led to the design shown on the drawings. These requirements are imperative to facilitate future modifications or alterations. When non-structural components or equipment are braced to new or existing structural or non-structural elements, structural calculations are required to demonstrate the adequacy of supporting elements.

F. Independent Structural Design Review

1. The RDP's structural design calculations, drawings, and specifications shall be reviewed by an Independent Third Party structural engineering firm specializing in seismic design. The review will be arranged and paid for by LBNL at Design Development phrase and 50% and 100% Contract Document phases. The RDP's schedule shall allow a minimum of two (2) weeks for each review and the RDP shall be required to respond to the design critique (without additional fee) to the satisfaction of the University. Interpretations of codes and comments by the third party reviewer will be advisory to the University. Final interpretations of codes and disposition of the third party review comments will be the

responsibility of the University. Independent third party review is optional and at the discretion of the Laboratory Building Official for one- and tow-story wood-framed buildings of less than 3,000 square feet, buildings not intended for human occupancy, and small projects that the Laboratory Building Official determines do not alter any building lateral force resisting systems.

G. Modifications to Existing Buildings

1. An existing building that is to be modified, altered, or added to must be re-evaluated for seismic performance when one of the following occurs:
   a. There is a change in the building's function that results in an increase in the building's level of use, importance, or occupancy;
   b. A project is planned that significantly extends the building's useful life through alterations or deferred maintenance that total more than 25 percent of the replacement cost of the building;
   c. The number of people, calculated as a weighted average, that will occupy the building increases by 25 percent or more;
   d. The building or part of the building has been damaged as a result of a natural phenomenon or other event to the extent that, based on evaluations performed by qualified professional engineers, significant structural degradation of the building's vertical and/or lateral load carrying systems has occurred;
   e. When an alteration or addition to the building results in either a greater than 10 percent reduction in the capacity of the building's lateral-load support system or a greater than 10 percent increase in the lateral loads being applied to the building;
   f. When an alteration or addition to the building results in a structural irregularity as defined by ASCE 7.
2. Seismic evaluations must be performed by qualified and California Registered Structural Engineers under the supervision of the Facilities Division Structural Engineer.
3. Seismic evaluations must be in accordance with the current versions of Department of Energy standard DOE-STD-1020, the University of California Seismic Safety Policy, and the California Existing Building Code (California Code of Regulations, Title 24, Part 10).
4. For existing buildings with a Seismic Performance Level Rating of V (“Poor”) and higher:
   a. No new or additional operations that result in personnel being exposed to the seismic hazard are permitted unless the building structure is upgraded;
   b. Funding must be requested to upgrade the building structure in accordance with the California Building Code and the current practice of earthquake engineering, as specified by the University of California Seismic Safety Policy. A phased rehabilitation program may be permitted for selected facilities when funds for seismic rehabilitation are limited.

H. Specifications

1. LBNL will provide the following specification section for incorporation into the construction documents. The RDP shall use “track changes” on the LBNL standard specifications and submit for LBNL approval of the changes. The RDP shall not modify or change this specification section without the express approval of LBNL.

013523.11	Lateral Force Provisions

2. LBNL will provide the LBNL Master Specification sections for incorporation into the construction documents. The RDP shall select the specification sections appropriate to the project, review those sections, edit them to suit the project using “track changes”, and submit a marked-up copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

   Structural design elements are covered under the following specification divisions:

Division 02	Existing Conditions (if required)
Division 03	Concrete
Division 04	Masonry
Division 05	Metals
Division 06	Wood, Plastics & Composites

6. GENERAL MECHANICAL REQUIREMENTS

The requirements under General Mechanical Requirements are applicable to building HVAC systems, Facilities Monitoring and Control System (FMCS/Energy Management), building process piping systems, plumbing systems, fire sprinkler systems, and site mechanical utilities systems.

A. General

1. The ventilation system shall provide a sufficient volume of outdoor air as called for in Paragraph D.1.d, below. The system shall maintain occupied areas at design conditions shown in “HVAC Design Criteria” (Paragraph D below).
2. Unoccupied high bay areas may deviate from these temperature guidelines, to be determined on a case by case basis.
3. Quality Assurance: The design for all mechanical systems, including HVAC, plumbing, fire protection, interior and exterior utilities, above and below ground, shall show all detail necessary for subcontractors to estimate the cost of construction within +/-10%. Systems shall conform to all applicable codes and the requirements listed herein and are fully capable of performing their intended functions.
4. Calculations: The RDP shall perform engineering calculations to support the mechanical design. Standard, recognized computation techniques shall be used; shortcut methods and rules of thumb are not acceptable. All assumptions shall be clearly stated with supporting documents referenced. The calculations and assumptions shall be properly indexed and bound, signed, and dated by the designer and checker; approved and stamped by a registered professional engineer holding a valid Mechanical Engineer license in the State of California; and presented as part of the design package. A procedure equivalent to the LBNL procedure as shown in "Checking of Architecture and Engineering Documents," RD3.8 of the CDDG, Volume 4 – RDs, shall be used to ensure that the calculations have been developed in an orderly and consistent manner.

   The HVAC systems load calculations shall be equivalent in detail to latest ASHRAE Fundamentals Handbook. The RDP shall use equipment sizing software or hand calculations. When modeling a building’s energy loads and/or consumption on a computer, the RDP shall use a commercially available and industry standard package such as eQuest, DOE2, or TRACE, and the final model shall be delivered to LBNL. Proprietary software or spreadsheets that are not commercially available shall be approved by LBNL before being used for this project. The mechanical equipment shall be sized to meet its peak load.

5. Equipment Numbering: Appropriate numbers in accordance with the LBNL Equipment Numbering System will be provided by LBNL during the 50% Construction Document (CD) design phase for all new equipment. The LBNL Equipment Number System is a unique 9-space alpha-numeric identifier for each individual piece of equipment. These numbers shall be used by the RDP and shall be correctly indicated on the 100% design drawings. It is the responsibility of the RDP to provide a list of all new and/or replaced equipment to LBNL for appropriate equipment tag assignment. All replaced equipment shall receive new equipment numbers and shall be reflected as such on the design drawings. The types of mechanical equipment and their abbreviations for which LBNL numbers shall be assigned are as follows:

AC	AIR CONDITIONING UNIT	GDS	GAS DETECTOR SENSOR
ADR	AIR DRYER	GH	GAS (SPACE) HEATER
AF	AIR FILTER	GP	GENERAL PUMP

AHU	AIR HANDLING UNIT	HU	HUMIDIFIER
ARU	ASSEMBLED REFRIG. UNIT (CHILLER)	KC	AIR OR GAS COMPRESSOR
BAS	BLDG AUTOMATION SYSTEM	MP	MECHANICAL VACUUM PUMP
BFP	BACKFLOW PREVENTOR	PC	PRESSURE CONTROLLER
BGM	BLDG GAS MAIN	PH	PH METER
BL	FAN OR BLOWER	PRD	PRESSURE RELIEF DEVICE
BR	BOILER	PRS	PRESSURE REDUCTION STATION
CF	CHEMICAL FEEDER	PV	PRESSURE VESSEL
CR	CRANE	REG	PRESSURE REGULATOR
CT	COOLING TOWER	SD	SMOKE DETECTOR
DP	DIFFUSION PUMP (HIGH VACUUM)	SDP	STORM DRAIN PRIMARY
DSD	DUCT SMOKE DETECTOR	SDS	STORM DRAIN SECONDARY
EX	HEAT EXCHANGER	ST	STEAM TRAP
FDA	FIRE DAMPER, AUTOMATIC	UH	UNIT HEATER
FH	FUME HOOD	VA	VALVE (AIR)
FL	FILTER	VAV	VARIABLE AIR VOLUME BOX
FP	FIRE PUMP	VG	VALVE (NATURAL GAS)
FPU	FIELD PROCESSING UNIT	VL	VALVE (LCW)
GBX	GLOVE BOX	VM	VALVE (MANUAL)
GD	GAS DETECTION SYSTEM	WFS	WATER FLOW SWITCH
GDP	GAS DETECTION PANEL	WH	WATER HEATER
WM	Water Meter	FM	Flow Meter
RO	Reverse Osmosis System	HRU	Heat Recovery Unit
CHB	Chilled Beam	RAM	Radiant Manifold
FSD	Fire & Smoke Damper	AS	Air Separator
CGF	Ceiling Exhaust Fan		

6. Piping Terminology: The RDP shall use the following piping terminology and abbreviations. Any deviations or additions to abbreviations below shall be reviewed by LBNL Engineering Manager.

AW	ACID WASTE	IHW	INDUSTRIAL HOT WATER
AWV	ACID WASTE VENT	LV	LAB VENT
CHWS	CHILLED WATER	LW	LAB WASTE
CA	COMPRESSED AIR	LCWS/	LOW CONDUCTIVITY
DCW	DOMESTIC COLD WATER	NG	NATURAL GAS
DHW	DOMESTIC HOT WATER	SS	SANITARY SEWER
DIW	DE IONIZED WATER	SV	SANITARY VENT
HHWS /R	HEATING HOT WATER	TRWS /R	TREATED WATER
ICW	INDUSTRIAL COLD WATER	TWS/ R	TOWER WATER
SD	Storm Drain	VAC	Vacuum

7. Non-Experimental Mechanical Safety Systems: Specialized safety expertise shall be applied to mechanical systems serving areas containing toxic chemicals and/or

radioactive materials. Mechanical designs will be reviewed by LBNL's Mechanical Safety Subcommittee prior to release of construction documents for construction.

8. Seismic Considerations: All supports, vibration isolators, and tie-downs for equipment and piping shall be designed in accordance with LBNL "Lateral Force Design Criteria," RD3.22, of the LBNL CDDG, Volume 4 - RDs. The RDP shall review vibration isolation requirements of all equipment and provide the appropriate isolation design and details. Locations of the longitudinal and transverse seismic bracing shall be shown on the ductwork and piping Floor Plans. Design details of the longitudinal and transverse seismic bracing based on Lateral Force Design Criteria as described in the General Structural Requirements section of this document shall be provided in the Mechanical and Piping Floor Plans of the contract documents.

9. Hangers and Support: The design shall include the support of piping and ductwork as required to prevent sagging, noise, or excessive strain on piping or ductwork under both operating and static conditions. Hangers and supports shall be designed to support the combined weight of the pipe or ductwork, fluid, and pipe or ductwork insulation, and shall have a minimum safety factor of five (5), based on the ultimate tensile strength of the material used; base calculations on equipment's heaviest operating weight and pipes full of water. All support components shall conform to the LBNL Master Specifications. The RDP shall design pipe and ductwork hangers close to the point of change of direction of pipe in either the horizontal or vertical plane. Pipes and ducts installed on the roof shall be provided with a minimum of 2 feet clearance between the bottom of the pipe or duct and the roof for roofing repair. Access platforms for crossing over utilities and ducts shall be indicated on drawings unless the ducts and utilities are routed with the bottom a minimum of 5 feet above the top of the roof. Pieces of equipment, perforated tape, wire, rope, wood, nails, or other makeshift devices shall not be used to support the weight of any pipe or ductwork, vertical or horizontal.
10. Abandonment Policy: No above-ground mechanical equipment or utilities shall be abandoned in place. All unused or replaced electrical or pneumatic controls must be identified on the mechanical demolition plans. No abandoned signal wires, signal tubes or FPU panels shall be left in place.

B. Auditoriums, Meeting Rooms

1. The HVAC system for auditoriums and meeting rooms without windows, and large office spaces without windows, shall be supplied off the main building air handling unit. If it is necessary that have a separate air handling unit, they shall be equipped with both supply and return fans.

2. Supply air shall have one fan system for cooling, heating and ventilation air. Variable air volume controls shall be used to avoid the use of excessive air volumes while in the heating mode. Care shall be taken to insure comfort while in heating mode.

3. The HVAC system shall have demand control ventilation (DCV) based on Co2 levels.

4. The supply system shall distribute air throughout the room at velocities that shall provide a cooling effect to all occupants, i.e., displacement ventilation. The supply system shall provide air near the occupant level to avoid short cycling into the exhaust or return.

C. Facility Monitoring and Control Systems

See Section 8 of the CDDG Design Requirements.

D. HVAC Design Criteria

1. Design and Heat Transfer Factors: Use factors specified in the latest California Energy Commission Nonresidential Manual for Compliance with the Energy Efficiency Standards for Nonresidential Buildings, etc., Title 24, Part 6. Use Region X weather data for Berkeley, California, at 0.1% DB and 0.5% mean coincident wet bulb (MCWB) temperature.

   a. Outside Design Temperature

	Summer	Winter
Laboratories:	90°F db/64°F 0.1%mcwb	33°F db
Data Processing:	90°F db/64°F 0.1%mcwb	33°F db
Offices and All Other:	83°F db/63°F 0.5%mcwb	33°F db

   b. Inside Design Temperature

	Summer	Winter
Laboratories:	72°F + 2 db	72°F + 2 db
Data Processing:	85°F	85°F
Exterior Offices:	76°F ± 2 db	70°F ± 2 db
Interior Offices, Other:	73°F ± 2 db	70°F ± 2 db
Electrical & Mechanical Rooms:	95°F	95°F

   c. Minimum Design Supply Air Temperature

Data Processing:	60°F db
All Other:	55°F db

   d. Minimum Design Outdoor Air Ventilation Rate

Laboratories:	1 cfm/sq. ft. Laboratories shall be provided with 100% outdoor air. Minimum ventilation rate applies to supply air rate for positively pressurized laboratories and applies to exhaust air rate for negatively pressurized laboratories.
Data Processing:	15 cfm/person, 0.15 cfm/square foot, whichever is greater.
Restrooms/ Janitor Closets:	Per Title 24 California Mechanical Code.
Industrial Facilities:	Refer to ACGIH Industrial Ventilation Manual
Offices and All Other:	Per Title 24 California Mechanical Code and California Energy Code.

   e. Relative Humidity

Data Processing:	To be specified in the PDR
All Other:	Uncontrolled, unless specified in the PDR based on the research requirements or user.

For Data Processing areas where there is active humidity control, vapor transmission barriers shall be designed into new floors, walls, and ceilings. The barriers shall be sufficient to restrain moisture migration during the maximum expected vapor pressure difference between the surrounding areas and the value required to meet specified conditions in the computer room.

f. For cooling tower selection use the 0.1 percent design wet bulb conditions (66 degrees) per latest Region X data.

2. Identify duct pressure classes on the ductwork plans, that is 1/2, 1, 2, etc., inside a triangle (refer to Sheet Metal & Air Conditioning Contractors' National Association, Inc. (SMACNA) HVAC Duct Construction Standards, Figure 1-1).
3. Use round ducts whenever possible.
4. Provide low-pressure, unducted return air systems whenever possible to reduce fan energy and reduce initial construction cost.
5. Air Filtration
   a. Refer to Title 24 California Mechanical Code, section 408.0, for filter requirements.
   b. Designs shall be based on ASHRAE Standard 52-76 efficiency test:

	Pre-Filter	Final Filter
Laboratories:	25%	90%
Data Processing:	35%	75%
All Other:	50%	
Electrostatic:	Do not use	

E. Mechanical System Noise

1. Designs shall be based on the most recent ASHRAE HVAC Applications Handbook, recommendations regarding room criterion RC(N) for each occupancy type. Use the more restricted RC(N).

	Maximum RC(N)
Laboratories with Fume Hoods	50
Data Processing	50
Corridors and Utility Areas	45
Open Plan Offices	40
Control Rooms	40
Offices and Libraries	35
Conference Rooms and Viewing Areas	35

2. Terminal units, such as VAV boxes, shall be located outside of auditoriums, meeting rooms, and private offices in adjacent hallways or adjacent open office spaces where possible to reduce noise in these spaces.
3. For large Meeting Rooms, Auditoriums, etc. (where more stringent controls are desirable), consult with the University's Representative to set standards suitable for the intended uses. Design all other areas within the NC standards recommended in the most recent ASHRAE handbooks.
   a. Inform the University's Representative during the Preliminary Design phase if high cost sound control measures shall be necessary.

F. Ventilation Criteria for Research Laboratories: hazardous materials that are used or stored in Chemical, Biological, or Radiological Research require special ventilation.

1. Room Ventilation

   a. New laboratory building ventilation systems shall be designed to minimize exposure to airborne hazards from hazardous materials to be used or stored in the laboratory. The number of laboratory air changes per hour is dependent on the hazards, heat, and/or odors to be controlled. The laboratory recommended criteria is six (6) air changes per hour during occupied periods and four (4) air changes per hour during unoccupied periods in the absence of specific conditions that require alternative air change rates.

   b. Primary animal housing shall use ventilated cages where possible. The ventilation system for primary animal housing and treatment areas shall provide six (6) air changes per hour with 100 percent exhaust to the outside when ventilated cages are used. The ventilation system for primary animal housing and treatment areas shall be capable of providing fifteen (15) air changes minimum per hour with 100 percent exhaust to the outside when ventilated cages are not used. Room pressure shall be negative to all adjacent areas. The air distribution device shall be designed to create a "no draft" environment.

      (1) No re-circulation of laboratory exhaust air to the building air supply.

      (2) Both supply air and exhaust air shall be ducted. Open-air plenums are not allowed.

      (3) Animal rooms within mixed-use buildings shall be on a separate, dedicated HVAC system.

      (4) All exhaust blowers for laboratory, chemical storage cabinet, fume hoods, biosafety cabinets (if needed), and their ancillary components such as controllers, VFDs, sensors, etc., shall be provided with standby power (UPS is not needed unless specified in the project specific PDR).

2. Room Air Pressure Differential

   a. Laboratories and clean rooms static pressure with respect to corridors, offices, and adjacent spaces shall be maintained as follows, unless specified otherwise by the application or user:

	Corridors	Offices	Adjacent
Laboratories	-0.02	-0.02	-0.02
Clean rooms	+0.02	+0.02	+0.02

   b. All exhaust systems that are designed to operate on standby or emergency power must be specifically designed to allow egress from affected spaces during a power outage. Exhaust fans must not hold doors closed when operating on backup or emergency power.

3. Chemical Fume Hoods

   a. Special containment (ventilated storage cabinets, special local exhaust, etc.) may be required for extremely noxious operations (muffle furnaces, etc.) or extremely odiferous materials (mercaptans, sulfur compounds, etc.). Toxic gases (arsine, phosphine, etc.) require ventilated cabinets with alarms. All fume hood controls including face velocities, exhaust dampers, and exhaust blowers, etc., shall be provided with backup power supply.

   b. Fume Hoods and Gas Storage Cabinets:

(1) Fume hoods shall be variable air volume except where specifically indicated by the application. Hood exhaust valves shall be capable of full shut off. General exhaust valves or units shall be provided if necessary to provide laboratory exhaust airflow when fume hood exhaust valves are fully shut off.

(2) Furnish sensors and controls to maintain a constant face velocity through the open sash of each fume hood or gas storage cabinet regardless of the sash position. Sensors, face velocity indicators, and controllers shall be provided with standby power (UPS is not needed unless required in the project specific PDR).

(3) Room pressure shall be controlled to maintain correct, safe pressure(s) relative to adjacent spaces. Provide Magnahelic gauge to indicate internal duct pressure of the exhaust duct immediately downstream of the air volume damper.

c. Hazardous Materials Storage Cabinets Under Fume Hoods:

(1) Flammable Materials Storage Cabinets: Provide on the back of the cabinet two (2) openings constructed with Factory Mutual approved flash-arrestor vents that can be plugged both internally and externally or opened for ventilation. One (1) opening shall be located near the top of the cabinet and the second opening shall be located near the bottom. Connect top opening to a 2-inch diameter Type 304 stainless steel supply vent pipe, and connect bottom opening to a 2-inch diameter Type 304 stainless steel exhaust vent pipe. Connect supply vent pipe to the upstream of the VAV box and connect exhaust vent pipe to the downstream of the fume hood air volume damper. Connections shall be welded, or flanged and sealed, and shall be routed to the back of the fume hood and the cabinet.

(2) Corrosive Materials Storage Cabinets: Provide on the back of the cabinet two (2) openings. One (1) opening shall be located near the top of the cabinet and the second opening shall be located near the bottom. Connect both of these openings to a single 2-inch diameter PVC pipe. Connect the cabinet vent pipe to downstream of the fume hood air volume damper. Connection to the primary exhaust duct shall be flanged and sealed and shall be routed to the back of the fume hood and the cabinet.

(3) Vacuum Pump Storage Cabinets: Three (3) vent openings shall be provided on the cabinet. One (1) opening shall be located at the back near the top of the cabinet and is identified as vacuum pump cabinet exhaust opening. Two (2) other openings shall be drilled on site at the back or the top, as directed by the users. These two (2) shall be identified as vacuum pump vent openings. The vacuum pump cabinet exhaust opening shall be 2-1/2 inches (63 mm) diameter, and connected to the exhaust vent duct downstream of the fume hood air volume damper. The vacuum pump vent openings shall be 2 inches (50 mm) diameter, or smaller if required by the user, one (1) for the pipe connection to the inlet of the pump and one (1) for the outlet. Pipe connection to the inlet of the pump shall be as directed by the users. If the openings are at the back, the outlet pipe from the pump shall be connected to downstream of the fume hood exhaust air volume damper. If the openings are drilled at the top through the fume hood work surface, the openings shall be provided with lips minimum 1/4inch high above the work surface. The pump outlet pipe shall vent into the hood.

(4) Satellite Accumulation Area (SAA): Provide on the back of the cabinet two (2) openings constructed with Factory Mutual approved flash-arrestor vents that can be plugged both internally and externally or opened for ventilation. One (1) opening shall be located near the top of the cabinet and the second opening shall be located near the bottom. Connect top opening to a 2-inch diameter Type 304 stainless steel supply vent pipe, and connect bottom opening to a 2-inch diameter Type 304 stainless steel exhaust vent pipe. Connect supply vent pipe

to the upstream of the VAV box and connect exhaust vent pipe to the downstream of the fume hood air volume damper. Connections shall be welded, or flanged and sealed, and shall be routed to the back of the fume hood and the cabinet.

4. Biosafety Cabinets and In-Place HEPA Filters

   a. All biosafety cabinets shall be tested per National Sanitation Foundation (NSF) Standard 49 or manufacturer's specifications after installation. The University's Representative shall forward the testing results to EHS for review.

   b. Class II Type B biosafety cabinets shall be installed on a dedicated exhaust system.

   c. Exhaust in-place HEPA filters shall be of the bag-in/bag-out type.

5. Glove Boxes

   a. Glove hood (box) may be required for special applications using highly toxic, extremely reactive, or California Occupational Safety and Health Act (COSHA) regulated chemical carcinogens.

   b. Glove boxes shall meet ANSI standard Z9.5, "Standard on Lab Ventilation" and the American Glove Box Society Standard, "Guidelines for Glove Boxes."

6. Other Specialty Hoods and Local Exhaust

   a. Histology hoods, specimen hoods, and other local exhaust specialty hoods require a minimum operating face velocity of 100 fpm with a range of 100-120 fpm.

   b. An audible/visual flow alarm may be required depending on use.

7. Exhaust Stack Height

   a. Stacks shall terminate a minimum of ten (10) feet above the working surface. Additional height may be necessary depending upon local conditions such as parapet screens, etc., which shall be determined during project design. Comply with 2013 Title 24 California Mechanical Code section 506.9.

   b. Stack discharge velocity shall be at least 3,000 fpm directed upwards. Lower stack discharge velocities may be acceptable if stack heights are extended and wind tunnel study is performed to ensure acceptable performance. Caps, deflectors, or similar impedances to smooth upward air flow are not permitted.

   c. Blower housings shall be equipped with drain holes located at the lowest point of the discharge airstream, and stacks shall drain directly into the blower housing without horizontal runs of ductwork. Direct all drain discharges from fans and AHUs to sanitary sewer system with sufficient trap height. The trap height design shall be detailed in the drawings.

   d. The results of a wind tunnel evaluation may necessitate a higher stack height.

8. Manifolded Laboratory Exhaust Systems

   In new laboratories, or laboratories in which the exhaust ventilation system is replaced, all laboratory exhaust shall be manifolded.

9. Air Cleaners

   Special air cleaning devices may be required for some fume hood applications as required by the Bay Area Air Quality Management District (BAAQMD).

G. Outside Air Ventilation Criteria for Non-Laboratory Settings

New building ventilation systems for offices, auditoriums, conference spaces, and bathrooms shall be designed to provide a healthful indoor air quality environment.

1. Office Spaces

   The ventilation rate shall be the larger of 15 cfm/person of outside air and 15 cfm/sf of outside air.

2. Auditoriums and Conference Spaces

   The ventilation rate shall be the larger of 15 cfm/person of outside air and 15 cfm/sf of outside air. Demand Control Ventilation (DCV) based on CO2 levels shall be provided for auditoriums and each individual conference room.

3. Restrooms

   The exhaust rate shall be greater than or equal to 75 cfm/fixture of outside air. Fixtures include urinals and toilets. Make-up air to be provided by door undercuts or other passive, low-pressure path. Restroom exhaust fans shall be controlled by an occupancy sensor and timer and shall turn off after the restroom has been unoccupied for 20 minutes.

H. Wind Tunnel Studies

1. A wind tunnel evaluation is required for all new construction that produces emissions of a hazardous, noxious, odoriferous, or otherwise nuisance character and that poses a health and safety risk. Common emission sources can include laboratory exhaust, cooling towers, generators, incinerators, kitchen exhaust, and vent stacks.
2. A wind tunnel evaluation may be required for remodeling projects if new exhausts are being added that may impact sensitive receptors or when the total volume of exhaust is being substantially increased or when the project may be affected by nearby existing buildings. Sensitive receptors can include air intakes, courtyards, operable windows, or sensitive animal populations, that are either part of the facility being remodeled or that exist nearby.
3. The required dilution is based on the chemical makeup of the exhaust and the type of receptors that are affected. Target dilution factors are 1/1,000 at minimum, as measured from the top of the exhaust fan to the receptor in question. For highly toxic emissions where a 1/1,000-dilution factor is inadequate, the appropriate dilution level shall be calculated for the specific application.
4. Chemical parameters to be evaluated include, but are not limited to: worst case spill releases and modeling with chemicals possessing highest toxicities, greatest volatility, and lowest threshold limit values (TLV).
5. The wind tunnel study chosen shall use best available technology and current industry testing standards. The latest ASHRAE Handbook of Fundamentals or the Environmental Protection Agency (EPA) Guideline for Fluid Modeling of Atmospheric Diffusion, EPA-600/8-81-009 shall be consulted. At minimum, the wind tunnel study shall take into account probable evaporation times based on ventilation rates, exhaust stack height and diameter, exit velocity, exhaust location, wind speed and direction, building features, and any nearby features that could influence emission dispersion.

I. HVAC Zoning

Distinct temperature and pressurization control zones shall be provided for individual laboratories; distinct temperature control zones shall be provided for corner offices, conference rooms, restrooms, computer equipment rooms, and other special use rooms. Exterior offices facing the same direction may be placed on the same zone, up to a maximum of four (4) offices per zone. Interior offices and hallways in the same area of the building may be placed on the same zone, up to a maximum of four (4) offices per zone. Each of the offices or other occupied space that is included in a zone shall have an independent temperature sensor and occupancy sensor. Each branch duct leading to a diffuser, grille, or louver shall be equipped with a manual balancing damper as close to the take-off as possible.

J. HVAC Plant

1. Boilers: Boilers shall be fully condensing (return water temperature not greater than 120°F) and have an efficiency rating of not less than 90% at winter design conditions.
2. Chillers: Chillers shall be water-cooled or employ an evaporative condenser and have an IPLV (ARI Standard 550/590-98) rating of not greater than 0.6 kW/ton (water cooled) or 0.65 kW/ton (evaporative condenser). Provide chillers with ability to turn down and operate at 25% of normal load for a long period of time (greater than 12 hours continuously).
3. Cooling Towers: Cooling towers shall be fiberglass or stainless steel, including tower basin, with the fan motor driven by a variable speed drive to control supply water temperature. Cooling tower filtration system shall be centrifugal type with a basin sweeping system. All cooling tower parts including filtration system shall be non-combustible and shall be approved by Factory Mutual (FM). Water treatment system shall be of a design reviewed and approved by LBNL. Cooling tower fan gear boxes driven by a motor on a VFD shall be rated for low speed operation.
4. Pumps: Pumps shall be selected for minimum energy consumption at the design flow rate and pressure drop. Dedicated isolation valves shall be provided upstream and downstream of the pump.
5. Piping: Pipes shall be sized for no greater than 4 feet of friction loss per 100 feet of pipe. Pipe sizes that are not commonly available such as 5-inch diameter pipes shall not be used.
6. Selection of HVAC Systems: For the 100% Preliminary Design submittal, the RDP shall select the HVAC systems based on LBNL requirements for capacity, performance, health and safety, standard mechanical equipment, spatial relationships, lowest life cycle cost, reliability, flexibility, and maintainability. The air handling system shall be designed to minimize simultaneous heating and cooling. Outside air economizer dampers and controls shall be provided on all systems employing return air, except where temperature, humidity, or pressure control is a requirement for the program and outside air shall adversely affect its operation. Water-cooled economizers shall be required on water-cooled HVAC systems.
7. Coils: Each heating and cooling coil shall be provided with isolation valves, a strainer, Pete's plugs, a control valve, and a circuit setter. Circuit setters shall not be used as isolation valves. Provide with copper fins and copper tubes for the coils.
8. Ductwork: Risers shall be sized for no greater than 0.08 inch of friction loss per 100 feet of duct or for a maximum velocity of 1,000 fpm, whichever is more conservative. Duct mains that are upstream of terminal units, such as VAV boxes or exhaust valves, shall be sized for no greater than 0.25 inch of friction loss per 100 feet of duct with maximum

velocity of 2,500 fpm for round ducts or 2,200 fpm for rectangular ducts. Ductwork that is downstream of terminal units shall be sized for no greater than 0.15 inch of friction loss per 100 feet of duct.

9. Variable Frequency Drives (VFDs): Pump and fan motors shall be controlled by VFDs when loads served by these units vary as a function of their normal operation. Additional requirements for VFDs are included in Section 13, Sustainability Requirements. All VFDs shall be tuned to lock-out the frequencies that cause excessive vibration or noise. In addition, the VFD shall be programmed to meet the operational requirement. Plug and play is not acceptable. Motor shall be rated for inverter duty. Shaft shall be grounded to prevent premature bearing failure.
10. Insulation "R" values: Walls shall be insulated to minimum R19 and roofs shall be insulated to minimum R30 when newly constructed. When adding or making modifications to the envelope of an existing building, insulation shall be added to walls and roofs with "R" values as close to these as possible, unless proven to not be life cycle cost effective by energy analysis.
11. Glazing: When adding or making modifications to the envelope of an existing building, any modified glazing shall be double-pane type with low-e coating and inert-gas filled.
12. Riser Diagrams

    For systems serving multiple floors, riser diagrams shall be provided. The riser diagrams shall be substantially complete for the 50% Final Design submittal.
13. Schedules

    Equipment schedules shall be provided for all air handling units, air conditioning units, fans, blowers, terminal devices, chillers, cooling towers, boilers, pumps, heat exchangers, coils, valves, and all other mechanical equipment required to show the minimum capacities and design basis of equipment for the project. For small projects, these items may be located on the mechanical title page, or first mechanical drawing. The schedules shall be substantially complete for the 50% Final Design submittal including accurate LBNL equipment numbers.

K. Health and Safety: The HVAC mechanical equipment design shall meet all statutory requirements which apply to the hazardous materials inventory statement (HMIS) supplied by LBNL. In addition, air handling systems shall meet all code requirements for smoke detection and shutdown.

L. LBNL Standard Mechanical Equipment: The RDP shall design the systems for this project using the mechanical equipment standards described in individual LBNL Master Specifications. The RDP shall provide alternatives to the standard equipment described in the LBNL Master Specifications that shall improve the efficiency, maintainability, and operability of the equipment. All motors shall be highest efficiency available (refer to specification in Division 23).

M. Spatial Relationship Requirements: Equipment arrangements shall allow for all code clearance (mechanical, pumping, and electrical) requirements. Equipment with accessories or appurtenances that extend beyond the footprint of a piece of equipment shall have their clearances determined from the outermost part of the accessory (e.g., chiller trim shall be considered to be part of the chiller envelope).

N. Life Cycle Cost Analysis (LCCA): The variables which shall be factored into a LCCA include first cost of construction, equipment replacements, and annual operating and maintenance expense. Contact the LBNL Mechanical Engineer for guidance on energy, labor, and escalation rates. All detailed calculations shall be included with the Selection of HVAC Systems data for 100% Preliminary Design. At a minimum, LCCA shall be used to determine the least life cycle cost options for the following:

1. HVAC System Design such as pre-cool, dual ducts, low velocity, heat recovery, etc.
2. Chiller options such as variable frequency drive, condensing, etc.
3. Boiler options such as highest available efficiency.
4. Air Handling Unit configuration such as dual fan for dual ducts.
5. Filtration system such as electrostatic filter versus standard pre-filter and final filter.

The design team members shall provide additional options for equipment and systems selection using LCCA.

O. Reliability

All systems shall be designed for an availability of greater than 98% on an annual basis during occupied hours. Critical applications such as laboratory exhaust, central plant equipment, and equipment serving data processing areas shall be designed with N + 1 redundancy. The LBNL standard mechanical equipment defined in individual LBNL Master Specifications have been chosen in part because of reliable operation. If new specifications are developed for this project, the RDP shall select equipment of equal or better reliability to the LBNL standard mechanical equipment and shall be approved by LBNL Facilities Engineering Department.

P. Flexibility

The mechanical equipment shall be sized to meet its intended load, plus 20% spare capacity. For data processing areas, spare CHWS/R, TRWS/R, or TWS/R connections for an additional 20% of the number of units to be installed shall be provided so that additional units may be put in place without a shutdown of the entire system. For central plant equipment in multiple-unit configurations, the piping to or from the pumps shall be arranged per the discretion of the RDP and approved by Facilities Mechanical Engineering. A primary-secondary system and piping configuration to enable one pump to serve more than one unit shall be provided. The system shall maintain an N+1 reliability, and the system must meet

the sustainability goals of the project per the discretion of the RDP and approved by Facilities Mechanical Engineering.

Q. Maintainability

Equipment arrangements shall allow for all maintenance access requirements, filter access, tube and coil removal space, lay down areas, VAV boxes, control valves, and any other clearances necessary for safe operation, maintenance, and repair of all equipment to be provided. Provide factory recommended service clearance around equipment or a minimum of 36 inches around equipment. Provide a minimum of 2 inches clearance between the outer diameter of the insulation of the largest piping component installed on each pipe rack. All circuit setter balancing valves shall be readable by the operator without help from a mirror. All insulation shall be installed to prevent damage caused by external moisture such as condensate or rain. High point vents and drains shall be provided at each branch line or cross main.

R. Specifications

LBNL will provide specifications for those items required on the project which are covered by LBNL Master Specifications. These Master Specifications shall be edited by the RDP specifically for this project using “track changes” for LNBL review after the systems and components have been selected during Preliminary Design. The specifications to be provided by LBNL are listed herein. All other specifications required for the project shall be developed by the RDP.

Division 09	Finishes
Division 11	Equipment
Division 14	Conveying Equipment
Division 23	HVAC
Division 25	Integrated Automation
Division 41	Material Processing and Handling Equipment

1. New Specifications Content: The RDP shall include only those specification sections required by the project components and shall ensure that all references to other sections are appropriate or deleted.
2. All materials and /equipment specified by the RDP shall bear the Underwriters Laboratories (UL) label or be approved by Factory Mutual (FM) where UL labels or FM approval is available to the type of products specified.
3. The RDP shall insure that formal training is included as a specification item for all equipment which shall be unique at LBNL as a result of this project. That specification item shall reference the LBNL Master Specification Section 017900 for Overall Training and Demonstration Plan. The length of the training shall be specified by the RDP and shall be long enough to provide adequate information transfer. The training content shall be specified to include information on the installation, operation, and maintenance of the equipment. The training shall be conducted by the vendor or manufacturer's representative within two (2) weeks of the date of activation of equipment. An outline of the proposed training program shall be submitted for approval at least two (2) weeks before the scheduled training start date.
4. The RDP shall insure that complete maintenance and& operation documentation is specified for all equipment for which new specifications are developed for this project.

7. GENERAL PLUMBING REQUIREMENTS

A. General: Plumbing systems include acid waste, acid waste vent, compressed air, domestic city water, domestic hot water, deionized water, industrial cold water, industrial hot water, lab vent, lab waste, low conductivity water, sanitary sewer, sanitary vent, indirect loop of process cooling water, treated water, compressed air, vacuum, and reverse osmosis. The following criteria apply to building plumbing systems and up to 5 feet beyond the building exterior wall.

B. Water, BTU, & Gas Meters

1. All metering shall comply with metering requirements in LBNL's Sustainability Standards for New Construction.
2. Provide each new building, or portions of new buildings and cooling and heating plants with separate meters for water, BTU and gas. These meters shall be connected to the FMCS. Meters shall be adequately sized and approved by LBNL's Energy Management Engineer.
3. Portions of existing buildings, and large additions or remodels of existing buildings, also require separate metering. Verify all requirements with the University's Representative. These meters shall be connected to the FMCS.
4. Whole building: gas and water shall be metered. Whole building BTU metering of chilled water or heating hot water shall be provided if building shares a central plant with other buildings. Whole building water meters shall be compound meters, which have the ability to measure high and low flow, which is essential for leak detection and to capture consumption during low flow.
5. Cooling towers: make-up and blow-down water shall be metered. These meters shall be connected to the FMCS.
6. Chiller plants: shall be metered with ultrasonic BTU meters with insertion type temperature sensors. These meters shall be connected to the FMCS.
7. Heating hot water plants: shall be metered with ultrasonic BTU meters with insertion type temperature sensors. These meters shall be connected to the FMCS.
8. Boilers: shall be metered with gas meters with pulsers with 1 cubic foot/pulse resolution. These meters shall be connected to the FMCS.
9. All water make-up supplies shall be metered. All drainage to sanitary sewer shall be metered. These meters shall be connected to the FMCS.

C. Plumbing Fixtures:

1. Provide WaterSense compliant fixtures.
2. Provide pint (0.125 gallon) flush urinals.
3. Dual-flush toilets.
4. Low-flow showerheads.
5. Waterless urinals are not allowed.
6. Provide low-flow sinks in restrooms.
7. Provide full-flow sinks in laboratories and breakrooms.
8. Automatic, battery-operated faucets, toilet flushers, or urinal flushers are not allowed due to extensive maintenance requirements.
9. Electric Domestic Hot Water (DHW) Heaters: shall be used instead of gas-fired DHW heaters where possible. Electric DHW heaters shall use heat recovery off of chilled water return loop where possible.
10. Gas-Fired Domestic Hot Water (DHW) Heaters: Gas-fired DHW heaters shall be fully condensing. The DHW supply piping shall be configured as non-recirculating, with a minimum of 1.5 inches insulation and sufficient for freeze protection.
11. Provide each new building with a hose bib at 100 feet maximum spacing along exterior walls.

D. Health and Safety: The plumbing systems design shall meet all statutory requirements which apply to the hazardous materials inventory statement (HMIS) supplied by LBNL.

E. Spatial Relationship Requirements: Equipment arrangements shall allow for all mechanical, plumbing, and electrical code clearances requirements. Equipment with accessories or appurtenances that extend beyond the footprint of a piece of equipment shall have their clearances determined from the outermost part of the accessory.

F. Reliability: Critical applications such as central plant equipment and equipment serving data processing areas shall be designed with N+1 redundancy. The LBNL standard mechanical equipment defined in individual LBNL Master Specifications have been chosen in part because of reliable operation. If new specifications are developed for this project, the RDP shall select equipment of equal or greater reliability to the LBNL standard mechanical equipment.

G. Flexibility: The plumbing systems shall be sized to meet the intended load, plus 20% spare capacity. Sectional isolation valves shall be provided at each end of the branch line tee from the cross main.

H. Maintainability: Equipment arrangements shall allow for all maintenance access requirements, lay down areas, and any other clearances necessary for safe operation, maintenance, and repair of all equipment to be provided. Provide vendor recommended clearance for all equipment or a minimum of 36 inches around equipment. Provide a minimum of 2 inches clearances between the outer surface of the insulation of the largest piping component installed on the pipe rack. All circuit setter balancing valves shall be readable by the operator without help from a mirror. All insulation shall be installed to prevent damage caused by external moisture such as condensate or rain. High point vents and low point drains shall be provided at each branch line or cross main. Low point drains shall be drained to sanitary sewer system with proper air gap.

I. Piping, pipe hangers, supports & bracings:

1. Pipes shall be sized for no greater than 4 feet of friction loss per 100 feet of pipe.

2. All piping which is installed underground and thereby subject to an unacceptable amount of corrosion shall be protected by bituminous coating, or other suitable means. Protection systems which do not rely heavily on workmanship in the field are preferred.

3. Pipe Hangers: Place hangers close to point of change of direction of pipe in either horizontal or vertical plane. Do not permit any valves, pump, or other piece of equipment to support the weight of any pipe, vertical or horizontal.

4. Readjust hangers with the piping system in hot or operating temperature condition so that hanger rods are vertical and piping is at proper grade and is uniformly supported by all hangers.

5. Piping Support: All support components shall conform to the LBNL Master Specifications. Do not support piping by perforated tape, wire, rope, wood, nails, or other makeshift devices. Support piping as required to prevent sagging, noise, or excessive strain on piping under both operating and static conditions.

6. Hangers and supports shall be designed to support the combined weight of the pipe, fluid, and pipe insulation, and shall have a minimum safety factor of five (5), based on the ultimate tensile strength of the material used.

7. Locations of seismic bracing shall be indicated on the drawings.

8. Locations of high point vents and low point drains shall be indicated on the drawings. All low point drains shall be drained to the sanitary sewer system with proper air gap.

J. Backflow Preventers (BFP): Backflow preventers shall be specified the same size as the piping. A reduced pressure type of backflow preventer shall be used to separate the industrial water system from domestic water system. All piping downstream of backflow preventers shall be clearly labeled as "non-potable Industrial Cold or Hot Water" for the industrial water system. Backflow preventers shall be approved by the Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California. The backflow preventer assemblies shall be reduced pressure principle type. The bottom of the BFP shall be installed a minimum of 12 inches above the concrete pad and the top of the BFP shall not be higher than 48 inches.

K. Process Piping Stub-out: All process piping including domestic hot and cold water systems, with the exception of sanitary sewer and lab waste, shall be installed in an overhead distribution system with valved stubouts approximately every ten (10) feet, center to center.

L. Specifications

LBNL will provide technical Master Specification sections for incorporation into the construction documents. The RDP shall review the specification sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Division 22 Plumbing

8. FACILITY MONITORING AND CONTROL SYSTEM (FMCS) REQUIREMENTS

A. The FMCS employs a multi-level distributed processing architecture connected by a local area network. The FMCS capabilities shall include all monitoring and control functions defined by the RDP during the Design Development (DD) and Contract Document (CD) phases of the design. Control sequences of all mechanical and plumbing systems shall be developed and provided. The control sequence diagram and the Sequence of Operation (SOP) for FMCS shall be documented in a Piping and Instrumentation Diagram (P&ID). See detail requirements below on the development of P&ID. P&IDs shall be provided in additional to the traditional Riser Diagrams. HVAC Control sequences shall be developed based on current industry standard practices for optimal energy efficiency. ASHRAE Guideline RP-1455 shall be used as the guiding document for high performance sequences. Current Title 24 guidelines shall be followed.

B. Preliminary HVAC and plumbing system sequencing schemes shall be submitted in the conceptual design phase for pre-approval by LBNL Energy Management Engineer.

C. Substantially completed control sequences shall be submitted in the 50% Construction Document (CD) drawings for review & approval by LBNL Energy Management Engineer. The control sequences shall be part of the Piping & Instrumentation Diagram (P&ID)

1. Piping and Instrumentation Diagrams (P&ID) shall be developed and provided for each HVAC system including air handling, chilled water, tower water, heating hot water systems, each temperature control zone, laboratory ventilation, heat recovery system, solar water heating system, etc. Typical mechanical & plumbing systems are Industrial Hot Water (IHW), Treated Water (TRW), Low Conductivity Water (LCW), Deionized Water (DIW), Compressed Air (CA), Vacuum System (VAC) and any other closed looped system.

   The P&ID shall include the rated capacities of major equipment as well as design air and water flows, temperatures, and pressures for each piece of equipment and room served. The flow and control P&ID shall show all mechanical equipment monitored and controlled. Balancing valves and dampers on each branch of piping and ductwork shall be included on the flow and control diagrams and in the project. The P&ID shall indicate all FMCS AI/AO/DI/DO points, all interaction with the electrical system (i.e., monitor, voltage, source, VFD, etc.), all LBNL assigned Asset Tags, as well as the normal position of all valves/dampers in the systems (NO/NC).

2. Each air flow P&ID shall show the relative placement of ductwork, dampers, actuators, filters, coils, valves, air handling units, air conditioning units, blowers, exhaust and return fans, condensers, smoke detectors, terminal devices, sensors, power source, normal operating condition, upset and emergency operating condition, and any other equipment which has an effect on the temperature, pressure, or flow in the air systems for this project.

3. Each heating flow P&ID shall show the relative placement of piping, boilers, pumps, heat-exchangers, coils, valves, steam traps, sensors, power source, control FPU, normal operating condition, upset and emergency operating condition, and any other equipment which has an effect on the temperature, pressure, or flow in the heating hot water system for this project.

4. Each chilled water P&ID shall show the relative placement of piping, chillers, cooling towers, pumps, heat-exchangers, coils, valves, sensors, power source, control FPU, normal operating condition, upset and emergency operating condition, and any other equipment which has an effect on the temperature, pressure, or flow in the chilled water system for this project.

D. Sequence of Operation: The RDP shall detail the sequences of operation on the P&ID for each system. The sequence of operation shall be designed to provide maximum operational

flexibility while system operation matches the demand as closely as possible. Each distinct piece of equipment shall have its own sub-section. Control routines and algorithms shall be consistent with current LBNL practices. Statements such as "Shall be controlled in the most energy-efficient manner possible" are specifically not acceptable. ASHRAE Guideline RP-1455 shall be used as the guiding document for efficient sequences of operation. The sequence of operation shall describe in detail the following:

1. A system description including equipment type and area or other equipment served. This shall include an alphabetized list or detailed description of the terminal units (VAV, FCU, etc.) served by each piece of major equipment.
2. For each piece of equipment, the conditions under which it is turned on and off, such as normal occupancy times.
3. For sub-components such as valves and dampers, the conditions under which each item is modulated, opened fully, or closed fully.
4. For variable setpoints, the conditions which cause the setpoints to vary, and what the resulting setpoints are.
5. Minimum and maximum values for setpoints or hardware limitations such as minimum outside air damper position.
6. All controlled HVAC shall be provided with occupancy schedules, including both occupied and unoccupied setpoints. The triggers for different modes, such as cooling, heating, night setback, night purge, morning warm-up, optimal start, and economizer shall be well defined and documented in the P&ID.
7. Occupant override capabilities designed into the system. This override shall allow the system to operate up to two hours during normally unoccupied periods.
8. Alarm conditions for controlled equipment and analog and digital input sensors.
9. A list of the points associated with this system and their hardware address.
10. System shall be designed to include a form of staged equipment startup following a power failure. The FMCS shall include a single-page interface for the operator to specify startup delays for all major equipment in a building.
11. The hardware design shall include all sensors, transducers, valves, and all other control points required by the sequences of operation.
12. Sensing devices and valves shall be appropriately placed to provide the necessary feedback and be easily maintained.
13. Meeting and Conference room locations shall be provided with a demand controlled ventilation using an Air Quality Sensor.

E. FMCS Input/Output Points List and Communication Diagram

1. Input/Output (I/O) points shall include every real sensed or control point connected to the FMCS. For every point, the list shall include a point ID, description of the point's function, FPU panel number, point type, and comments. The FMCS I/O Points List shall be substantially completed for the 50% Construction Document submittal.
2. All controllers shall be tested, certified, clearly stamped and listed by the BACnet Testing Laboratories (BTL).
3. A FMCS communication diagram shall be provided which shows the circuits required between the FPU panels in single-line format. The FMCS communication diagram shall be substantially completed for the 50% Final Design submittal.
4. All required communication circuits shall be identified.
5. No Gateways, Communication Bridges, Protocol Translators or any other device that translates any proprietary or other communication protocol to the BACnet communication protocol shall be permitted as a part of the FMCS. Gateways may only be used as required for communication to existing systems.

6. All network and device numbering must be reviewed and approved by LBNL Energy Management Engineer before implementation. This includes IT connections, IP addresses, DNS names, BACnet network numbers, BACnet device IDs, etc.
7. Miscellaneous monitoring points required for the space shall be defined in list form the 50% Construction Document Drawings. These points include but are not limited to the following:
    a. standby diesel generator units as specified in the General Electrical Requirements section of this document,
    b. specialized energy monitoring sensors,
    c. freezer or chemical storage system alarms,
    d. automatic transfer switches,
    e. toxic gas monitoring systems
    f. leak detectors,
    g. utility meters such as water, gas, electricity and steam,
    h. occupancy sensors,
    i. additional requirements as specified in the Project Design Requirements (PDR).
8. Thermostatic controls must be provided for each space-conditioning zone to control the supply of heating and cooling energy within that zone. Space-conditioning zones shall not incorporate multiple space types. Exceptions to be approved by an LBNL Energy Management Engineer.
9. Each room included in a zone shall have an independent temperature sensor and occupancy sensor. Meeting and Conference rooms shall have in addition to these an Air Quality Sensor. Exclusions to be approved by LBNL Energy Management Engineer.
10. HVAC systems with DDC to the zone level must be programmed to allow centralized demand shed (Automatic Demand Shed Controls) for non-critical zones.
11. Economizer Fault Detection and Diagnostics (FDD) must be included in the controls for all newly installed air-cooled unitary direct-expansion units, with mechanical cooling capacity at AHRI conditions of greater than or equal to 54,000 Btu/hr. (4.5 tons), and equipped with an economizer. The system shall be specified in a way that allows transmission of the FDD information to LBNL Facilities Department.
12. Mechanical space-conditioning systems supplying heated or cooled air to multiple zones must include controls that automatically reset the supply-air temperature in response to representative building loads, or to outdoor air temperature. The controls must be capable of resetting the supply-air temperature by at least 25 percent of the difference between the design supply-air temperature and the design room air temperature.

F. The FMCS platform shall be chosen by LBNL Energy Management Engineer during the conceptual design phase of the project. This decision shall be based on current and future planning for FMCS modernization. Assumptions shall not be made by the RDP based on the current FMCS that is installed in an existing space. Current systems in use are:
    1. Automated Logic WebCTRL
    2. Johnson Controls Metasys Extended Architecture

G. Field Processing Unit (FPU)

1. Each new FMCS control panel shall be given a distinct Field Processing Unit (FPU) number by LBNL following Design Development review.
2. Each FPU shall have a minimum of 20% spare-point capacity.
3. An FPU Panel Schedule shall be on the design drawings and shall include the panel number, electrical circuit, whether the panel is on normal, standby or emergency power, and a description of the equipment being controlled from this panel. It is anticipated that this shall be a preliminary design and shall be updated by the contractor during the construction process, with the contractor providing information for the as-built drawing set. The BACnet operating stack must be embedded directly in every device at the board level, and in all operator interface software packages.
4. Each Field Processing Unit (FPU) panel that resides on the Ethernet level shall have a dedicated data drop from an LBNL network switch. These data drops shall be shown on the Telecom plans at the 100% drawing review and any modifications shall be recorded in the as-built drawing set.

H. Refer to the Electrical Requirements, Section 12 - Electrical Meter Requirements, for Energy Recharges. Specifications

I. LBNL will provide technical Master Specification sections for incorporation into the construction documents. The RDP shall review the specification sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Division 25 Integrated Automation

9. FIRE PROTECTION REQUIREMENTS

A. General

1. Fire Protection Subconsultant: The RDP shall obtain the services of a California licensed Fire Protection Engineer for this project. A Small Business vendor who has produced a significant number of designs for LBNL is HYT Corporation, 3498 Clayton Road, Suite 101, Concord, CA 94519, (925) 681-2731 voice, (925) 681-2733 fax.
2. Level of Design: The RDP shall provide a complete package for the fire protection systems with detailed drawings and calculations. The drawings provided by the RDP shall include detailed pipe layout with dimensions, hanger, and support locations, fittings, components, and accessories. Drawings and calculations shall be approved by a Fire Protection Engineer registered in California. Coordinate with the LBNL Fire Marshal and Facilities Mechanical Engineer prior to design of the system. Drawings shall be completely integrated with existing drawings.
3. Codes and Standards: For new construction, the fire protection system shall meet all applicable codes and standards in effect when design commences (code of record). These codes and standards shall remain in effect for the life of the facility. When modifications to facilities are of a substantial nature, as determined by the authority having jurisdiction, the current edition of the code shall apply to the modification. EXCEPTION: If there is a significant hazard that endangers building occupants or the public, the facility shall be upgraded to the requirements of the current edition of the code or standard.
4. Hazard Classification: Sprinkler coverage shall be for Ordinary Hazard Group 2 with a minimum design area of 2,500 square feet, using the Density/Area curves from NFPA 13, Chapter 11. All sprinkler systems shall be of the wet pipe type. Sprinkler systems serving a large computer room or data center shall be pre-action systems.
5. As-Built Fire Sprinkler Drawings: Any LBNL as-built record drawings showing the fire protection systems in the area affected by the project shall be provided to the RDP upon request.
6. Hydraulic Calculations: When modeling a building's fire protection hydraulic system on a computer, the Fire Protection Engineer shall use a commercially available package (refer to the LBNL Master Specification Section 211313). Proprietary software or spreadsheets that are not commercially available shall be approved by LBNL before being used for this project.
7. Health and Safety: The fire protection system shall meet all applicable codes and standards in effect when design commences (code of record). In addition, the fire protection system design shall meet all statutory requirements which apply to the hazardous materials inventory statement (HMIS) supplied by LBNL.
8. Flexibility: New fire protection mains shall be sized to meet the intended load, plus 20% spare capacity.
9. Maintainability: Equipment arrangements shall allow for all maintenance access requirements and any other clearances necessary for safe operation, maintenance, and repair of all equipment to be provided. High point vents and drains shall be provided at each branch line or cross main without removing a sprinkler. All drains shall be directed to outside of the building or to a sanitary sewer connection with a minimum 3-inch air gap.
10. Fire protection specifications shall be provided. Refer to LBNL Master Specifications:

Division 10	Specialties
Division 21	Fire Suppression

B. Fire Alarm and Mass Notification Systems

1. Fire Alarm and Mass Notification System Sub-consultant: For this project, RDP shall obtain the services of a California licensed Fire Protection Engineer to perform engineering and to prepare construction drawings and specifications for the Fire Detection and Alarm System. A small Business vendor who has produced a significant number of designs for LBNL is HYT Corporation, 3498 Clayton Road, Suite 101, Concord, CA 94519, (925) 681-2731 voice, (925) 681-2733 fax.
2. The RDP shall coordinate with the California licensed Fire Protection Engineer in preparing raceway layout, riser diagram, special control wiring, and schematic drawings.
3. The new or modified Fire Detection and Alarm System shall be based on the existing building's Siemens Cerberus System-3 with interface to MXL and XLS-V system via existing or new MID-16 and existing MOI-7 modules, as described in LBNL Master Specification 283100, Fire Detection and Alarm, or Siemens Cerberus addressable system with XLS or XLS-V interface, as described in LBNL Master Specification 283110, Interior Fire Alarm and Mass Notification System. Mass Notification shall be included in the new system.
4. The Fire Detection and Alarm System in new building(s) shall be based on Siemens Cerberus addressable system with MXL and XLS interface, as described in LBNL Master Specification 283176.
5. The Sub-consultant shall use information from existing LBNL Fire Detection and Alarm System drawings for any modifications to the existing system under this project, and add new drawings as required in LBNL format to match existing drawings. Refer to the Fire Alarm System Design Standard Details in the LBNL CDDG, Volume 3 – Construction Details, Part VI – Electrical Details, for System 3, MXL, XLS or XLS-V details. The construction documents shall comprise of the following drawings and specifications, as minimum:
    a. Project Specification Section 283176 (as applicable).
    b. System Logic Diagram(s).
    c. Sequence of Operation Table and/or Description.
    d. Battery calculations.
    e. Fire Alarm and Mass Notification Control Panel Arrangement and Wiring Diagram(s).
    f. Building Transmitter Wiring Diagram(s).
    g. Initiation, Indication, and Notification Devices, Raceway and Wiring Layout(s).
    h. Initiation, Indication, and Notification Devices Wiring Diagram(s).
6. The Fire Detection and Alarm System shall have the following basic features:
    a. Transmission of signals to the Fire Alarm Control room in Building 48, and shall transmit offsite to the remote dispatch office via [MOI-7 module in existing System-3 panel inside the building][new XLS-V Panel inside the new building] and MXL Panels centrally located in the area.
    b. Local zone alarm(s) for the building: Audible/visual notification devices shall be provided in corridors, restrooms, conference rooms, and other areas accessible to the public to meet the ADA requirements. The audible notification devices shall be located to ensure that the minimum sound level meets the requirement of NFPA 72.
    c. The Fire Alarm Control Unit shall be located near the main entrance in a protected location as determined by the LBNL Fire Marshal.
    d. Emergency battery backup for system operation as required by NFPA72.

e. Supervisory devices for all critical functions (e.g., valve position switches, water level, temperatures, etc.).

f. Electrically supervised sprinkler water control valves and water flow alarms provided at building Fire Alarm Control Unit and Control Center in Building 48.

g. Capability of announcing at least three (3) separate conditions:

(1) Zone fire alarm.

(2) Zone supervisory signal.

(3) Trouble signal indicating a fault in either of the first two (2) conditions.

h. Refer to LBNL Master Specifications for wire numbering system of Fire Alarm circuits.

7. Add connection of fire alarm panel(s) in new buildings to centralized monitoring system at Building 48 through existing fire alarm fiber or copper loop.

8. LBNL will provide technical Master Specification sections for incorporation into the construction documents. The RDP shall review the specification sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Specification 283100	Fire Detection and Alarm
Specification 283110	MXL Fire Detection and Alarm System
Specification 283146.11	High Sensitivity Air Sampling Smoke Detection System
Specification 283176	Interior Fire Alarm and Mass Notification System

10. SITE MECHANICAL UTILITIES REQUIREMENTS

Applies to all underground piping systems except sanitary sewer, storm drain, and electrical ductbanks and conduits.

A. General

The RDP shall provide for all necessary demolition, relocation, and replacement of existing mechanical utilities within the project area if required by the scope of this project. Abandonment of systems and equipment in place is not allowed by LBNL policy.

B. Underground Requirements

All underground utilities shall be a minimum of 30 inches below the finished grade and shall include a metal detector tape a minimum of 6 inches above the utility.

C. Confined Space

Where applicable, the RDP shall clearly show on the subcontract documents that it is the contractor's responsibility to have and implement their own confined space program prior to entering any LBNL confined spaces. The contractor’s program and training record shall be submitted to and approved by LBNL Construction Safety prior to entry. The atmospheric testing of confined spaces shall be performed in the presence of the Project Manager or his/her representatives.

D. Dig Permit

The RDP shall insure that the requirement to obtain a permit to penetrate or excavate existing surfaces of LBNL property from the LBNL Facilities Division, prior to any excavations or ground penetrations, is clearly shown where applicable on the subcontract documents.

E. Site Mechanical Utilities Plan

The site mechanical utilities plans shall be dimensioned and show the locations of all piping, valves, pressure reducers, and all other equipment required to connect to the site utilities for this project. References to applicable enlarged plans, sections, and details shall be shown as required. Statements such as "See Civil Drawings" are not acceptable. Pipe sizes shall be shown. Design water quantities for each piping branch shall be shown or noted. All piping which is installed underground and thereby subject to an unacceptable amount of corrosion shall be protected by bituminous coating, or other suitable means. Protection systems which do not rely heavily on workmanship in the field are preferred. For the 100% Preliminary Design submittal, the site mechanical utilities plans shall show the approximate location of all buildings, equipment, and piping.

F. Specifications

LBNL will provide technical Master Specification sections for incorporation into the construction documents. The RDP shall review the specification sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Division 33 Utilities

The RDP shall provide for all necessary demolition, relocation, and replacement of existing mechanical utilities within the project area. No underground or above-ground mechanical equipment or utilities shall be abandoned in place.

11. SITE UTILITIES REQUIREMENTS

A. Provide a detailed utility plan showing onsite and offsite facilities, and their connections to existing site utilities. Show any portions of the existing system to be abandoned.

B. It is common for a project to be dependent on the construction of the specific utility facilities by another project or phase of the same project. The project shall coordinate with other known projects and master plans; utility system designs shall incorporate all phases and any off-site sewer that is required for the connection to an existing main.

C. Plans shall use the current utility sheets as a base map for utility plans and shall use the same coordinate system for all plans: California State Plane Coordinates, Zone II, NAD83.

D. Additions and deletions shall be drawn on new and separate layers. The layers shall be named for each utility as “Utility System Additions” and “Utility System Deletions.”

E. All new manholes, cleanouts, lift stations, wells, and other infrastructure shall be annotated with an empty identification bubble. The new structures shall have designators assigned by LBNL Facilities Plant Engineering staff to be included in the final bid documents. The project shall coordinate with University and include the designation numbers in the project design documents.

F. Investigate and clearly identify the need in the design documents to specify the order of work to ensure new facilities are in place before existing facilities are taken out of service, either temporarily or permanently, to reduce or eliminate interruptions to any utilities. For interruptions that can’t be avoided, provide a detailed Utility Shutdown Plan that identifies all utilities affected, how the utility shall be isolated, the estimated duration of the interruption, any by-pass or temporary services that the contractor shall be required to provide, and the proposed timing of the shutdown that shall be least disruptive to the University.

12. GENERAL ELECTRICAL REQUIREMENTS

A. General:

1. The applicable requirements of the edition of National Electrical Code (ANSI/NFPA 70) as included with the latest edition of the California Code of Regulations, Title 24, Part 3, shall be followed in the design of the electrical systems. In addition, the remaining codes, standards, and design references listed in this document shall be used in the preparation of drawings and specifications. The most stringent code, regulation, or standard shall be applied.

   The RDP and its sub-consultants shall become familiar with LBNL's Electrical Authority Having Jurisdiction (AHJ) Program as defined in LBNL PUB-3000 Chapter 8 Electrical Safety and the Facilities Installation AHJ Program (refer to LBNL Facilities Division link under www.lbl.gov) and shall design the electrical systems to enable full adherence to the requirements therein.

   The electrical systems shall be designed in such a way as to allow University Representative and Subcontractor to agree upon the amount of unfinished electrical work remaining prior to energization. The RDP shall identify the specific "Hold Point" in Specification Section 013500, Supplement B – Inspection, Test & Witness Hold Plan the electrical work that must be completed and inspected prior to building or project energization. The RDP may create an Electrical Work Completion Checklist on a drawing and specify that Subcontractor shall use the Checklist to develop energization sequences of the building or project in the Contract Documents.

   The recommended energizing sequence shall contain details and notes which the electrical subcontractor shall implement in preparing a coordinated energization plan to facilitate a logical and safe energization of the building or project and the subsequent start-up and commissioning of the project or building's electrical systems addressed in this section.

   The electrical subcontractor shall submit the energization plan to the University for approval when the electrical work is deemed by the University as being substantially complete. Energization may proceed once all the following requirements are met: electrical work is complete, all electrical equipment and wiring systems have been successfully acceptance tested, all test reports have been reviewed and approved by the University, the energization plan has been approved, and approval for energization has been obtained from Facilities Division Operations Department.

   The RDP shall specifically state in the Contract Document that using the Lock Out, Tag Out (LOTO) system to partially energize the building is prohibited, for example, energizing to a LOTO point while downstream work is incomplete, needing modifications, re-work, replacement, untested or not approved for energization under Electrical Authority Having Jurisdiction (AHJ) Program as defined in LBNL PUB-3000 Chapter 8 Electrical Safety and the Facilities Installation AHJ Program.

2. All underground utilities shall be a minimum of 30 inches below finished grade and shall include high voltage hazard warning tape a minimum of 6 inches above the utility. Duct bank installation shall comply with LNBL detail INS-106

3. Dig Permit: The RDP shall insure that the requirement to obtain a permit to penetrate or excavate existing surfaces of LBNL property from the LBNL Facilities Division, prior to any excavations or ground penetrations, is clearly shown where applicable on the subcontract documents.

4. All materials and equipment specified by the RDP shall be new and shall bear the UL label or be approved by a nationally recognized testing laboratory (NRTL). The equipment shall be within one (1) year of manufacture. No rebuilt, refurbished,

remanufactured, out of production, or used equipment and material shall be installed and wired under this project.

5. “Multiple Phases” and “Add Alternates” in a project, demolition, and modifications shall be shown on separate plans and elevations for clarity.
6. Raceway routing from the panels to the field devices/equipment shall be indicated on the drawings for power, fire alarm, security, public address, FMCS and/or other controls system, intercom, and CCTV systems. Indication of home runs for lighting and power circuits with circuit identification, conduit size, conductor size, and number of conductors shall be acceptable. However, the raceway system shall comply with the requirements of the Architectural Design Requirements section of this document for operation, maintenance, clearance, and equipment.
7. As applicable, the RDP and its Sub-consultants shall use information from LBNL’s “Existing Condition Source (ECS)” when developing project documents such as:
   a. One-Line Diagram(s), Motor Control Center One-Line Diagram(s).
   b. Piping and Instrumentation Diagrams (P&ID).
   c. Fire Alarm System [Logic Diagram(s), Fire Alarm Control Panel(s), XLS/MXL/MXLR/MX-203/MX-316 Transmitter Panel Connection Diagram(s)] [Riser Diagram, Raceway Layout(s), Connection Diagram(s)].
   d. Underground Manhole details.
   e. Security Access System [Riser Diagram, Raceway Layout].
   f. Paging System [Riser Diagram, Raceway Layout(s), Connection Diagram(s)].
   g. Arc Flash Hazard Evaluations.

   LBNL will provide available electronic files of all “Living Documents” in AutoCAD (latest version) format for the RDP’s use. All new project drawings for above systems shall follow the same format as the existing drawings. New project drawings shall have unique drawing numbers in sequence with the project’s drawings.
8. Equipment Numbering: Appropriate numbers in accordance with the LBNL Equipment Numbering System as described in Specification 260553 will be provided by LBNL during the 50% Final Design phase for all new equipment. These numbers shall be used by the RDP and shall be correctly indicated on the drawings. The types of electrical equipment and their abbreviations for which LBNL numbers shall be assigned are as follows:

ACB	AIR CIRCUIT BREAKER	EG	ENGINE GENERATOR
AD	AIR DISCONNECT	EGP	ENGINE GENERATOR PORTABLE
ADF	AIR DISCONNECT, FUSED	EL	ELEVATOR
AFD	AUTOMATIC FIRE DOOR	EPO	EMERGENCY POWER OFF
AIT	CURRENT INDICATING TRANSDUCER	EPS	EMERGENCY POWER SUPPLY
ALT	ALTERNATOR	FAB	FIRE ALARM BELL
AM	AMMETER	FAH	FIRE ALARM HORN
AR	AMPERE RECORDER	FAL	FIRE ALARM, LOW
ASF	AIR SWITCH, FUSED	FAP	FIRE ALARM PANEL
B	BELL	FAS	FIRE ALARM SYSTEM
BAT	BATTERIES (ELECTRIC)	FCP	FIREMANS CALL BOX
BC	BATTERY CHARGER	FD	FUSED DISCONNECT
BK	BANK TRANSFORMER	FDA	FIRE DAMPER, AUTOMATIC
BYP	BYPASS PANEL	MG	MOTOR GENERATOR
CAP	CAPACITOR BANK	OVR	OIL VOLTAGE REGULATOR
CDE	CONTROL DAMPER MOTOR	PNL	PANEL, CIRCUIT BREAKER

CTE	CURRENT TRANSFORMER	PSS	POWER SUPPLY/DISTR
DSD	DUCT SMOKE DETECTOR	RFD	REMOTE OPER FIRE DOOR
EAS	EMERGENCY ALARM SYSTEM	VCB	VACUUM CIRCUIT BREAKER

The RDP shall specify "HOLD POINTS" on the design drawings for LBNL to validate and verify that the equipment numbering is in compliance with Contract Documents. The "HOLD POINTS" shall include detail numbering sequences in spreadsheets showing electrical panel numbers.

9. The design of Power Distribution for a building shall be limited to three (3) deep, Main – Distribution Board – Panel Board. The maximum panel board rating shall be limited to 250 Amp for individual laboratory. Sub-feeding or "Daisy Chaining" of the Distribution Board or Panel Board is not allowed. Branch circuiting and feeder shall not be distributed from the same panel.

10. The Electrical Power Distribution system, including new systems and modifications to existing systems, shall meet the following requirements for limiting arc flash incident energy. Two Methods (A and B), are provided to meet these requirements. Method A requires that the final, as-built incident energy level is below the Maximum Incident Energy listed in Table 1. Where arc flash incident energy cannot be reduced below the limits in Table 1, then Method B requires other arc flash incident energy mitigation techniques to limit the effect of an arc flash, and to reduce arc flash incident energy levels as much as possible. The selection of Method B instead of Method A is subject to approval by the University.

Table 1:

115kV-12.47kV: Open Air Switches, Breakers, and Busbar	< 12 cal/cm^2 at 60 inches
12.47kV Metal Clad or Enclosed Switchgear, Transformer Disconnect Switches, Gas Switches	<12 cal/cm^2 at 36 inches
480V-208V Unit Substation secondary terminations to Line Side Main Breaker in LV Switchgear	<25 cal/cm^2 at 24 inches
480V-208V Load Side Main Breaker in LV Switchgear and feeder breakers, MCCs, switch and panelboards in Electrical rooms/Outdoor pads where access is by QEW	<12 cal/cm^2 @ 24 inches (LV Switchgear) and 18 inches (MCCs, switch, panelboards)
480V-208V Switchboard, MCC and panelboards in Mechanical rooms where access is by non-QEW	<4 cal/cm^2 @ 18 inches
480V-208V End User and Utilization Equipment: PDUs, Pwr Supplies, Panelboards, Disconnects, etc., in technical research or experimental areas of access, non-QEW, QWR	<1.2 cal/cm^2 @ 18 inches
480V-208V End User and Utilization Equipment: Panelboards, Disconnects, in areas of public access, non-QEW, QWR	<1.2 cal/cm^2 @ 18 inches

a. Method A – Arc Flash Incident Energy Reduction

The RDP shall design the Power Distribution System such that the Maximum Incident Energy listed in Table 1 is not exceeded in the final as-built condition, regardless of the status of energy-reducing maintenance switching (ERMS). Subject to review and approval by the University, the RDP may use engineering methods including but not limited to (see NFPA 70E, Annex O, Safety-Related Design Requirements, for additional information):
(1) Zone Selective Interlocking
(2) Differential Relaying
(3) Energy-Reducing Active Arc Flash Mitigation System
(4) Arc Flash Relaying
(5) Current Limiting Devices
(6) Equivalent methods, subject to approval

b. Method B – Arc Flash Incident Energy Mitigation

Where the limits in Method A cannot be achieved, and subject to approval by the University, Method B may be applied. Using Method B, the incident energy shall be reduced to "As Low As Reasonably Achievable" (ALARA). Consideration shall be given to modifications to existing installations, e.g. tenant remodels, equipment retrofits and replacements in evaluating what is achievable. The RDP may be required by the University to utilize arc-resistant switchgear or MCC's where applicable, listed to IEEE Std C37.20.7, to minimize the impact of an arc flash event, in which case the installation shall be such that venting of the blast is directed to a safe area outside of a building.

c. However, in all cases, regardless of whether Method A or Method B is selected, the following requirements shall apply:

(1) The arc flash mitigation design techniques shall use listed components and equipment.
(2) Energy-reducing maintenance switching (ERMS) shall be included where available
(3) Selective coordination shall be maintained.
(4) In no case shall the arc flash incident energy be allowed to exceed 40 cal/cm^2 without express written approval from the University

11. The RDP shall provide for all necessary demolition, relocation, and replacement of existing electrical utilities within the project area. No underground or above-ground electrical equipment or utilities shall be abandoned in place.

B. Design Calculations

1. The electrical system shall be designed so that all equipment and components operate within their capacities for the project electrical loads including future projected loads. The equipment shall be rated to withstand the system short circuit duty. As applicable, the following design calculations shall be performed and submitted for University's review and approval.
2. Electrical Studies: The latest version of the SKM Systems Analysis, Inc. PowerTools suite of software shall be used for items 1 through 6 below.

a. Short Circuit Study and Equipment Evaluation Study using [the Impedance Method] SKM Systems Analysis, Inc. software shall be used.

b. Protective Device Coordination Study
c. Arc Flash Evaluation in accordance with NFPA 70E at each piece of electrical equipment where power switching is accomplished (e.g., switchgear, switches, panels, motor control centers, breakers, etc.).
d. Load Flow and Voltage Drop Analysis.
e. Power Factor Correction Capacitor Bank.
f. Harmonics Analysis in accordance with latest IEEE standards, i.e. 519 etc. where applicable.
g. Electrical Grounding Analysis in accordance with latest IEEE standards, i.e. 80, 81 etc., where applicable to establish safe touch and step potentials for ground potential rise. This applies to new and modified systems where the RDP will provide the analysis and design to comply with standards.

3. Connected and Operating Electrical Load Estimate, including future projected load.
4. Compliance with the California Title 24 Energy Code.
5. Incident energy and safe limits of approach calculation in accordance with NFPA70E at each electrical equipment where power switching is accomplished (e.g., switchgear, switches, panels, breakers, etc.).
6. Special studies as may be required by the project (e.g., electromagnetic or radio frequency interference studies).

The following short circuit current values shall be used at the point of connection for performing above studies:

[12.47 kV 3-Phase Symmetrical Fault Current: _____ Amperes]
[480 Volt 3-Phase Symmetrical Fault Current: _____ Amperes]
[208 Volt 3-Phase Symmetrical Fault Current: _____ Amperes]
[12.47 kV Single Line to Ground Fault Current: _____ Amperes]
[480 Volt Single Line to Ground Fault Current: _____ Amperes]
[208 Volt Single Line to Ground Fault Current: _____ Amperes]

C. Equipment Clearances and Access

Coordinate with the RDP in implementing the requirements referred to in the Architectural Design Requirements section of this document for the maintenance envelope around equipment for access and repair. The following shall be followed as minimum:

1. Equipment arrangements shall allow for all code required clearances, maintenance access requirements, and any other clearances necessary for safe operation, maintenance, replacement, and repair of all provided equipment.
2. Equipment with accessories or appurtenances that extend beyond the footprint of a piece of equipment shall have their clearances determined from the outermost part of the accessory.

D. Electrical Power Distribution

1. For a new power distribution system, the RDP shall furnish a complete One-Line Diagram of the project's electrical distribution system from the LBNL point of connection to the utilization level.
2. For a new power distribution system, electrical circuits shall be separated by end-use for the categories of HVAC (heating, ventilation, and air conditioning), lighting, plug loads,

significant atypical loads, including high-performance computing clusters, data centers, server rooms, commercial kitchens, high-energy mission-specific facilities, and other (i.e., all remaining loads).

3. The One-Line Diagram shall incorporate circuit breaker frame and trip sizes, wire and conduit sizes, connected loads, spare circuit breakers, and fully equipped, “breaker ready” spaces for future additional breakers. For modifications to an existing distribution system, the RDP shall use information from existing LBNL One-Line diagram(s) to develop the project’s One-Line diagram(s). Panel schedules shall be prepared in LBNL format, furnished with this project in electronic file format.
4. If a 12.47 kV-480/277 Volt or 12.47 kV-208/120 Volt Unit Substation is required on the project, LBNL will procure the unit substation and associated automatic switching Power Factor Correction Capacitor Bank for installation on the project. This will maintain quality, reliability, and spare parts availability on site for future maintenance and equipment compatibility. Construction Subcontractor shall furnish all other equipment and materials.
5. The LBNL numbering system shall be used as described in the LBNL Master Specification 260553, Identification for Electrical Services. LBNL will provide transformer bank numbers as required.
6. Motors for building utilities, such as fans, air-conditioning, compressors, and pumps that are larger than 400 Watts (1/2 HP) shall be NEMA design B minimum and shall be rated for available 208 or 480 Volt, 3-Phase power with 120 Volt controls. In cases where both 208 Volt and 480 Volt are available in the building, 480 Volt, 3-Phase power shall be used to feed these motors. Motors rated 400 Watts (1/2 HP) or smaller shall be 120 Volt, 1-Phase. All motors shall be provided with shaft groundings.
7. Motor control centers, rated for 480/277 Volt or 208/120 Volt, 3-Phase, 4-wire, 60 hertz system, shall be provided for groups of motors. Motor starters shall be combination type with magnetic only breaker, solid state type overload protection, NEMA B class wiring, and pull-apart terminal blocks. Separate control power transformer with primary and secondary fuses shall be provided for each starter with control voltage not to exceed 120 Volt. A common control power transformer is acceptable only for a group of motors of a system that are being controlled by a common control panel. Thermal overload protection devices shall not be specified.

E. Standby and Emergency Power Distribution System

1. All generators installed at the Lab shall be categorized as Standby unless approved by LBNL. Standby power systems shall meet requirements of NFPA 110 Level [1] [2]. Battery powered lighting backup systems shall be provided so that a Level 2 generator is used instead of a Level 1 emergency generator. The standby power distribution system shall be fed from both normal and generator power via an automatic transfer switch equipped with an external maintenance by-pass feature. Upon loss of normal power, the transfer switch shall signal the generator engine to start and transfer the load to generator power upon buildup of voltage and frequency. Upon restoration of normal power, the switch shall transfer the load back to normal power and have the generator shutdown after an allowable cooling period. All controls shall be an integral part of the auto transfer switch. The switch shall be rated for the system short circuit duty and maximum operating load.
2. As a minimum, separate normal, standby/ and emergency power circuits shall be provided for fire alarm; access security; intercom and public address; voice and data systems; selected lighting; exhaust blowers serving fume hoods, glove boxes, and gas cabinets; energy management system controllers and field point units; electrical rooms and other research equipment requiring continuous operation. Typical research

equipment requiring standby power includes freezers and air conditioning units serving data centers. As the transfer to standby generator and vice versa is break before make type, auto-start controls shall be provided for such equipment upon restoration of normal or standby power.

3. Electrical equipment rooms and spaces shall have their lighting and half of the convenience outlets on standby power as well as battery powered emergency lighting units.
4. An uninterruptable power supply (UPS) shall be provided for critical equipment, which cannot sustain a momentary outage. Typical equipment requiring a UPS includes data center equipment, sitewide communications systems, or critical alarm systems. Data center UPS systems are usually sized to allow an orderly shutdown within approximately 15 minutes. Refer to the PDR for other sizing and performance requirements.
5. As a minimum, the following parameters shall be connected to FMCS controllers for status monitoring of the diesel generator unit and auto transfer switch at the FMCS monitoring station in Building 76:
    a. Generator DC battery AC power Failure, high and low DC Voltage.
    b. Common alarm from Diesel generator annunciator panel as listed in the LBNL Master Specifications.
    c. Auto Transfer Switch Positions: Normal and Standby.

F. Office and Laboratory Power system:

1. In general, each office (room) shall have 120 Volt, 20 Amperes grounded receptacles in accordance with the National Electrical Code. Additional receptacles shall be provided on the wall(s) to prevent appliance or equipment wiring crossing the doorway. Branch circuits for utilization equipment, convenience receptacles, and specific purpose receptacles shall be included as necessary to meet the needs of equipment and applicable requirements of the codes and standards.
2. Each laboratory shall have, on at least three (3) walls, surface mounted raceway with 120 Volt, 20 Ampere grounded receptacles spaced approximately [24 inches][__ inches] on centers. Standby power shall be provided to all laboratories as required by the PDR.
3. Utility receptacles (GFCI if required) shall be provided 18 inches above finished floor along the open aisle way in the laboratories, hallways, and corridors.
4. Receptacles with ground fault protection shall be provided for equipment requiring such protection in accordance with the codes and standards and as recommended by the research equipment suppliers.

G. Grounding

1. The building ground system shall consist of a perimeter grounding grid, utilizing driven ground rods with interconnecting copper cable that is not smaller than #4/0 AWG. All building steel, equipment grounds, and separately derived electrical power system neutrals shall be bonded to this grounding grid. A ground bar shall be provided near the main service entrance so that the integrity of the grounding system can be periodically checked. The grounding resistance shall comply with the requirements of IEEE Standards. Ground bus bars shall be provided in all electrical rooms and laboratories.
2. The ground grid shall be connected to the foundation re-bar of not less than 1/2-inch size at least at one (1) point in accordance with latest edition of NEC.

3. All underground ground or inaccessible wire connections, splices, and connections to building structures shall be made with exothermic welds.
4. If required, an isolated ground for the computer system or research equipment shall be provided with three (3) ground rods connected in a triangular form. The insulated ground wire shall be connected to these rods to maintain isolation throughout the circuit. This ground grid system shall be connected to the building ground only at one (1) place.
5. The following equipment shall be statically grounded with a #12 AWG minimum copper conductor to building structure, nearest ground grid, or suitable grounded structure: flammable material storage cabinets, satellite accumulation area (SAA) cabinets, fume hoods, bio-safety cabinets, glove boxes, specialty hoods, and other equipment specified in the PDR. The static ground conductor shall be protected by conduit where it may be exposed to damage.

H. Lighting & Lighting Control Systems

1. Wiring and Infrastructure
   a. Power for lighting systems shall be distributed via dedicated switchboards, panelboards and controls.
   b. Power distribution for lighting systems shall follow the three (3) deep requirements of paragraph 11.1.h.
   c. When available, 277 volt power shall be used for lighting systems.
   d. At least one lighting panelboard shall be provided on each floor or level of the building.

2. Design and Execution
   a. Maintenance

      (1) All lighting systems shall be designed to provide ease of maintenance.
      (2) Lighting fixtures shall be designed to replace lamps, ballasts, LED engines, LED drivers, and entire fixtures without shutting down power to the laboratory or unaffected adjacent spaces.
      (3) All lighting fixtures shall be designed to prevent extra safety measures such as LOTO.
      (4) All lighting installations shall be designed to reduce the need for scaffolding-based fall protection (e.g. ceiling mount luminaires in stairwells).
      (5) Lighting installations requiring the removal of sheetrock or drywall, removal of bulky or heavy access panels requiring two (2) persons shall not be acceptable.

   b. Illuminance and Uniformity Requirements

      (1) The lighting illumination shall comply with the most recent, published IES standards.
      (2) Interior Lighting
         (a) In general, the lighting system shall be designed for the following maintained illumination levels.

Interior Application Area	Type	Illuminance (lux) & gauge	Plane Location	Uniformity	Source
Control Room	H	300, avg	30" AFF	3.0 avg/min	IES Handbook 10th Edition, Table 30.2
	V	300, avg	@ display		
Data Center / Compute	H	500, avg	36" AFF	3.0 avg/min	ANSTI/TIA-942-A-

Interior Application Area	Type	Illuminance (lux) & gauge	Plane Location	Uniformity	Source
Room	V	200, avg	36" AFF		2012, 6.4.4.4
Laboratory General	H	500, avg	@ benchtop	4.0 avg/min	IES Handbook 10th Edition, Table 30.2
	V	150, avg	48" AFF		
Laboratory Benchtop with Task Light	H	1000, avg	@ benchtop	2.0 avg/min	IES Handbook 10th Edition, Table 30.2
	V	300, avg	48" AFF		
Offices	H	500, avg	30" AFF	3.0 avg/min	ANSI IES RP-1-12, Table B1k
	V	100, avg	48" AFF		
Corridor, Breakout	H	100, avg	0" AFF	3.0 avg/min	ANSI IES RP-1-12 Table B1l
	V	30, avg	48" AFF		
Stairs, High Activity	H	100, avg	0" AFF	2.0 avg/min	ANSI IES RP-1-12 Table B1m
	V	50, avg	60" AFF		
Lobby, Transition	H	100, avg	0" AFF	3.0 avg/min	ANSI IES RP-1-12 Table B1m
	V	50, avg	60" AFF		
Equipment Rooms	H	200, avg	36" AFF	3.0 avg/min	IES Handbook 10th Edition, Table 22.2
	V	150, avg	60" AFF		
Electrical Rooms	H	100, avg	36" AFF	3.0 avg/min	IES Handbook 10th Edition, Table 22.2
	V	100, avg	60" AFF		
Conference Rooms	H	300, avg	0" AFF	3.0 avg/min	ANSI IES RP-1-12 Table B1g
	V	75, avg	48" AFF		

(a) To convert the illumination levels above from lux to footcandles, divide by 10.
(b) Exterior lighting shall have a correlated color temperature of 3,000K.
(c) Exterior lighting in work areas such as mechanical yards, electrical switch yards shall have a correlated color temperature of 5,000K. Lighting in these areas shall have a local switch to turn the lights on once per night and a photocell to turn the lights off at daybreak. The lighting shall remain off until manually turned on the following night.
(d) Street lighting, if included in the scope, shall be designed per IES RP-08-12 using the luminance criteria for local roads.
(e) Equipment pads, if included in the scope, shall be designed using the interior lighting levels in the previous section.
(f) All exterior luminaires shall have a BUG rating equal to or less than 2-0-2. Luminaires on the perimeter of the campus shall be located to minimize light trespass while maintaining illuminance targets.

(3) Exterior Lighting
(a) In general, the lighting system shall be designed for the following maintained illumination levels.

Exterior Application Area	Type	Illuminance (lux) & gauge	Plane Location	Uniformity	Source
High Pedestrian Activity Conflict Zone (e.g. driveway)	H	20.0, avg	0" AFF	4.0 avg/min	RP-08-14, Table 4
	V	10.0, min	60" AFF		
Local/Local Intersection, High Pedestrian Activity	H	18, avg	0" AFF	6.0 avg/min	RP-08-14, Table 8
Local/Local Intersection, High Pedestrian Activity	H	14, avg	0" AFF	6.0 avg/min	RP-08-14, Table 8
Parking Lot/Garage, Concrete Surface Parking Area	H	10, min	0" AFF	4.0 avg/min	RP-20-14, Table 2 & 4
	V	5, min	60" AFF	15:1 avg/min	

Parking Lot/Garage, Asphalt Surface Parking Area	H	5, min	0" AFF	4.0 avg/min	RP-20-14, Table 2 & 4
	V	2.5, min	60" AFF	15:1 avg/min	
Pedestrian Walkways, High Activity	H	10.0, avg	0" AFF	4.0 avg/min	RP-08-14, Table 4
	V	5.0, min	60" AFF		
Pedestrian Walkways, Medium Activity	H	5.0, avg	0" AFF	4.0 avg/min	RP-08-14, Table 5
	V	2.0, min	60" AFF		
Path to Curb, High Activity	H	10.0, avg	0" AFF	3.0 avg/min	RP-33-14, Table 2b
	V	6.0, min	60" AFF		
Path to Curb, Medium Activity	H	6.0, avg	0" AFF	3.0 avg/min	RP-33-14, Table 2b
	V	2.0, min	60" AFF		
Path to Curb, Low Activity	H	2.0, avg	0" AFF	3.0 avg/min	RP-33-14, Table 2b
	V	2.0, min	60" AFF		
Covered Entrance, High Activity	H	30, min	0" AFF	4.0 max/avg	RP-33-14, Table 2a
	V	15, avg	60" AFF	2.0 avg/min	
Covered Entrance, Medium Activity	H	15, min	0" AFF	4.0 max/avg	RP-33-14, Table 2a
	V	8, avg	60" AFF	2.0 avg/min	
Covered Entrance, Low Activity	H	8, min	0" AFF	4.0 max/avg	RP-33-14, Table 2a
	V	4, avg	60" AFF	2.0 avg/min	
Uncovered Entrance, All Activity Levels	H	10, min	0" AFF	4.0 max/avg	RP-33-14, Table 2a
	V	15, avg	60" AFF	2.0 avg/min	
Gated Entrance, Pedestrian Access	H	8, avg	36" AFF	2.0 max/avg	RP-33-14, Table 2a
	V	8, avg	36-60" AFF	2.0 avg/min	
Gated Entrance; Cars, Light Trucks, Commercial Vehicles	H	15, min	36" AFF	2.0 max/avg	RP-33-14, Table 2a
	V	10, avg	36-60" AFF	2.0 avg/min	

(b) To convert the illumination levels above from lux to footcandles, divide by 10.
(c) Exterior lighting shall have a correlated color temperature of 3,000K.
(d) Street lighting, if included in the scope, shall be designed per IES RP-08-12 using the luminance criteria for local roads.
(e) Equipment pads, if included in the scope, shall be designed using the interior lighting levels in the previous section.
(f) All exterior luminaires shall have a BUG rating equal to or less than 2-0-2. Luminaires on the perimeter of the campus shall be located to minimize light trespass while maintaining illuminance targets.

c. Egress & Emergency Lighting
(1) Egress lighting shall be provided whenever a space is occupied
(2) Emergency lighting shall be provided in corridors, research areas, laboratories, electrical rooms and spaces, stairwells, and other public areas as identified in the architectural RDP's specified egress plan or as required by the Fire Marshal's Office for the entire egress path through the building and out to the Public Way.
(3) Emergency lighting shall be provided by either of the following:
(a) A twin-head emergency light with a ninety-minute battery back-up power packs connected to normal power lighting circuits.
(b) Selected fixtures of the general lighting system fitted with ninety (90) minute battery back-up power packs connected to normal power lighting circuit. These fixture must have a UL924 shunt to allow the fixture to be controlled (dimmed, turned off) during non-emergency situation.
(4) The emergency lighting system shall provide light levels equivalent as defined below:
(a) Corridors: 20 lux minimum, 30 lux average, 100 lux maximum
(b) Stairwells: 20 lux minimum, 30 lux average, 100 lux maximum

(c) All other area where egress lighting is required: 20 lux minimum, 30 lux average.

(5) Illuminated emergency “EXIT” signs shall be LED type fixtures with GREEN letters and UL Listed. The signs shall be completely solid state with a normal operating power of not more than 7 watts (single-faced) and 8 watts (double-faced). Exit signs shall be fitted with ninety (90) minute battery back-up power packs and be connected to the normal power lighting circuits. The location of the exit signs shall meet the ADA requirements.

(6) Protrusion limits: Objects with leading edges more than 27 inches (686 mm) and not more than 80 inches (2032 mm) above the finish floor or ground shall protrude 4 inches (102 mm) maximum horizontally into the circulation path, per 2010 ADA standards 307.2 Protrusion Limits.

d. Lighting Quality

(1) Interior Glare and Veiling Luminances.

(a) In spaces where computer use is expected, the RDP shall select luminaires consistent with Table 2 in ANSI/IES-RP-1-12.

1) The RDP shall consider the glare performance of occupants’ visual display terminals (VDTs) and limit the luminaire luminance above the appropriate cut-off angle.

2) To minimize the apparent brightness of luminaires in the visual field, all recessed luminaires in non-transition spaces shall emit no more than 300 candela above 65° from nadir, 195 candela above 75° from nadir, and 60 cd above 85° from nadir.

(b) Exterior Lighting shall be designed for safety, security, and aesthetics.

1) Safety involves minimizing conflicts with pedestrians, bicycles, and vehicles through channeling traffic to the safest paths, and providing adequate sight lines and lighting levels.

2) Security minimizes personal harm or property loss by achieving good visibility and by removing shadows along paths.

3) Aesthetics in lighting refers to the appearance and placemaking qualities of the lighting design, both during the day and night.

e. Temporary Site Lighting

(1) When exterior lighting is removed or de-energized for construction, the RDP shall require the Subcontractor to provide lighting in areas where this will be anticipated. The temporary exterior lighting shall be provided with illumination levels listed above.

(2) Temporary exterior light shall be provided during construction and shall be included in the contract documents. Incandescent lighting is prohibited unless justified to be life cycle cost effective.

f. Lighting Fixtures and Luminaires

(1) RDP shall submit the proposed fixture types and installation details to LBNL for review prior to Final Design.

(2) Interior Lighting

(a) General indoor lighting fixtures in offices, laboratories, shops, corridors, conference rooms, and areas with modular acoustical ceilings shall be recessed LED fixtures with LED engines and drivers; acrylic, prismatic lenses; and white reflectors.

(b) General indoor lighting fixtures shall be provided with replaceable light engines, lamp, drivers, and ballasts.

(c) Decorative fixtures shall be placed on a separate circuit or be provisioned with individually addressable (e.g. DALI) lighting controls.

(d) Fixtures and ballasts/drivers shall have the ability to dim to 1%.

(3) Emergency lighting
  (a) See section 2.c above.
(4) Exterior Lighting
  (a) All new buildings shall be provided with exterior lighting covering occupiable exterior areas.
  (b) Exterior lighting fixtures shall be LED. The exterior fixtures shall match the existing fixtures and installation in the vicinity of the project area and shall be provided with individual and fused driver.
  (c) Exterior lighting shall be compatible with the LBNL Exterior Lighting Control System.

g. Lighting Control Systems
(1) Interior Lighting
  (a) Lighting systems for new construction shall use a distributed lighting control system that shall be integrated into the building level FMCS system. Wired controls are preferred over wireless. If wireless sensors are provided, battery life shall be at least 10 years.
  (b) The Lab currently uses the Lutron Quantum lighting control system and strongly desires to maintain a single lighting control front end.
  (c) Building Schedule:
    1) The project building schedule shall be documented in the PDR with input from the University.
    2) Time-of-day or astronomic schedule-based controls systems shall be implemented via a networked lighting control system. Stand-alone timeclocks are to be avoided.
    3) Buildings with schedule-based controls systems shall provide override controls accessible near the building entrance to accommodate after-hours work.
  (d) Dimming
    1) The preferred dimming protocol is DALI.
    2) Fixtures and control systems shall have compatible dimming protocol. Where protocol is not compatible, provide gateways. All gateways need to be approved by an LBNL Energy Management Engineer.
    3) All lighting applications shall have task-tuning (i.e. top trimming) functions for a lumen maintenance control strategy.
  (e) Occupancy sensors shall be used to shut off lights when spaces are unoccupied.
    1) Exception: Light fixtures in rooms with electrical equipment, as defined in CEC, shall be zoned such that electrical equipment areas are manually controlled.
    2) Occupancy sensors shall cover 100% of the space.
    3) Occupancy sensors shall be installed 6 feet or more away from HVAC diffusers, air handlers, windows, and fans.
    4) Occupancy sensors shall not be installed directly above ceiling fans.
    5) Sound shall not be used as a secondary detection technology.
    6) In single person offices, lights shall turn on automatically to 50% and off automatically after 20 minutes of no activity in the space.
    7) In restrooms, lights shall turn on automatically to 100% and off automatically after 10 minutes of no activity in the space. Under no circumstances shall manual on (vacancy mode) sensors be utilized, nor shall the occupancy sensor provide an occupant-accessible override to disable the sensor.
    8) Where occupancy sensors are used to detect occupancy for demand-controlled ventilation (DCV), they shall be provided with an auxiliary relay (internal or external).

(f) All projects shall include daylighting controls to dim luminaires adjacent to windows and/or skylights.
1) Daylighting controls in transient occupancy areas (e.g. lobbies, corridors, stairwells) may use open loop occupancy sensors.
2) Spaces with long-occupancy periods (e.g. offices, laboratories, conference rooms) shall use closed-loop occupancy sensors. New construction projects shall include separately controlled primary and secondary sidelit zones.
3) Renovation projects of existing buildings shall include primary sidelit zones and may include secondary sidelit zones, so long as they are controlled separately.
4) Photocells shall be located per manufacturer instructions and shall not interfere with manual control of the window shades.

(g) All projects over 10,000 square feet shall include Demand Response.
1) General lighting shall dim by 20% and do so over 10 minutes.
2) Decorative fixtures shall dim by the same amount, or turn off, depending on the capabilities of the fixture.

(2) Emergency lighting
(a) See section 2.c above.

(3) Exterior Lighting
(a) Exterior lighting fixtures rated for 30 watts or more shall have fixture-integrated occupancy-sensor, 0-10V dimming and integrate with the Echelon exterior lighting control system.
(b) Exterior luminaires rated for less than 30 watts shall either ingrate into the Echelon system (meeting the requirements above) either separately (each luminaire) or by the lighting zone (a group of luminaires used in the same application or area).

(4) The interior lighting control systems shall be integrated with the site wide master control systems, as applicable for each manufacturer. The system shall also be integrated with the HVAC FMCS system.

I. Electrical Meter Requirements for Electricity Recharges

a. Provide each new building, or portion thereof, with a separate advanced electrical energy meter with capability of remote monitoring through LBNL's ION Enterprise system. The communication shall be via an Ethernet connection for master energy meters and RS-485 connection for slave energy meters with Modbus RTU protocol. Master energy meters shall communicate with the ION Enterprise system. Advanced energy meters shall be ION models manufactured by Schneider Electric or equivalent from Siemens.

b. The RDP shall prepare subcontract documents for metering communications raceway and wiring, meter programming, and ION Enterprise System database and graphic modifications for monitoring at Building 76 SCADA Control Room.

c. Large additions to or remodels of existing buildings may also require separate meters. Verify all requirements with the University's Representative and Energy Management Engineer.

d. Additional electricity metering requirements are described in the Sustainability Requirements section of this document

J. Site Utilities and Service to Buildings

a. All buildings shall be connected to existing site utilities on site. Verify all points of connection with the University's Representative.

b. All site utility services, including electric, telephone, fire alarm, etc., shall be underground. Power and communications/signal ductbanks shall have a minimum cover of 30 inches to top of concrete. Power and communications/signal ductbanks shall be separated by 24 inches, minimum, measured between conduits. Where power and communications/signal ductbanks cross with mechanical utilities, the power and communications/signal ductbanks shall be run under the mechanical utilities with a minimum separation of 6 inches between the top of concrete and the lowest mechanical system, unless a larger separation is required by the mechanical design or performance criteria. Duct bank installation shall comply with LBNL detail INS-106.

c. All buildings shall be pre-wired for telephone, data, FMCS, and fire alarm.

d. High security areas shall be pre-wired for security alarms and electronic access systems.

K. Harmonics: The following practices shall be reviewed with the University's Representative for incorporation into the project in order to reduce harmonics and provide quality power.

a. Provide full size separate/dedicated neutrals for each branch circuit.

b. Install full size ground wire in all electrical installations. Conduit and raceway systems are not to be depended upon for grounding.

c. Derate transformers or install K-rated transformers.

d. Size neutral conductor on all 3-Phase 4-wire panel boards by 200 percent of phase conductors.

e. Share neutrals of lighting circuits powered from 277 Volts if neutral is rated for 200 percent.

f. Electronic ballasts shall not have a total harmonic distortion greater than 10 percent.

g. Provide minimum conduit size of 3/4 inch from electrical panels to boxes and between boxes.

h. Do not fill new conduit runs more than 30 percent of capacity.

L. Security Alarm

Card Access and CCTV Security System

1. The card access security system shall be compatible with the existing card access system as described in the LBNL Master Specifications.
2. The CCTV security system shall have digital recording, minimum one-week stand-alone image storage, and network ability for remote access and backup of images. The system shall be password protected and user level programmable. The CCTV security system shall comply with the LBNL Master Specifications.
3. LBNL shall provide the RDP with the locations of existing card access controllers, card readers, door switches, power door hinges, request to exit sensing devices, CCTV cameras, and details of the CCTV control system between cameras and control unit.
4. For the card access and CCTV security system, the RDP shall provide a 4-foot by 4-foot backboard in the Communications closet with a 6-inch by 6-inch by 3 foot-0 inch long

wireway on the top. All low voltage card access and CCTV security system raceways from the field devices and equipment shall terminate in this wireway.

5. The RDP shall use information from existing LBNL access security drawings for any modifications to the existing system under this project and add new drawings as required in LBNL format. Refer to the Access Security System Design Standard Details in the LBNL CDDG, Volume 3 – Construction Details, Part VI – Electrical Details.
6. Card access security system shall be [fail safe][fail secured]. [In fail safe system, all door locks shall be unlocked for egress in case the security control system fails.][In fail secured system, all the doors are locked for entry from outside, but can be opened from inside for egress in case the security control system fails.]
7. CCTV monitoring and intrusion alarms shall report to an LBNL security office as specified in the program details.
8. The security system shall have [one (1)] [two (2)] [completely independent] communication link(s) to LBNL's host security computer via [dial-up modem] [and] [Ethernet network system]. Install conduits only.
9. All security equipment, door access devices and powered hardware shall have battery backup reserves for eight (8) hours of normal operating time furnished with the controllers located in the communication closet.
10. The RDP shall prepare the following drawings and specifications for installation under this project in LBNL format:

    a. Project Specifications.

    b. Card Access and CCTV Security System Title Sheet.

    c. Separate card access and CCTV monitoring riser diagrams.

    d. Construction drawings for installation of security system raceways, junction boxes for raceways and card readers, wireway, power hinges for the doors with card readers, raceways to communications closet wireway from field security devices, raceways between supervised devices, raceway and wiring to building standby power panel to a pull box for security system controllers including door details for security devices.

11. To maintain security system integrity and product warranty, the equipment, devices and wiring shall be installed by an approved construction subcontractor under a separate subcontract. The RDP shall prepare construction documents for this subcontract. In general, the security system installation package shall comprise of the following drawings and specifications:

    a. Project Specifications 281313.11, Card Access System, and 282300, Video Surveillance.

    b. Card Access and CCTV Security System Title Sheet, riser diagrams and raceway layout drawings for reference only, if no revision is required.

    c. Loading Schedule.

    d. Wiring Diagram for field devices, readers, panels, etc.

    e. CCTV camera layout and wiring diagram to control unit.

    f. Installation and wiring diagram for connection to the centralized monitoring office.

M. Public Address and Intercom Systems

1. Coordinate with the RDP in implementing the requirements referred to in the Architectural Design Requirements section of this document for Communication Closet(s) for telephone, card access and CCTV security, and public address systems.
2. The RDP shall provide a 4-foot by 4-foot backboard in the communications closet, bracket, or shelf for the amplifier units, raceways to communications closet from the field devices, raceways between speakers and amplifiers, raceway between intercom microphone and amplifier unit, standby power from emergency panel, speaker boxes, and supports.
3. The RDP shall use information from existing LBNL public address and intercom systems drawings for any modifications to the existing system under this project and add new drawings as required in LBNL format. The RDP shall prepare the following drawings and specifications for installation under this project in LBNL format to match existing drawings.
    a. Project Specification 275116, Public Address Systems.
    b. Intercom and Public Address system Riser Diagram(s).
    c. Raceway layout and wiring connection drawings for Paging and Communication system.

N. Integrated Communications System (ICS)

1. For retrofit projects, the RDP shall design raceways from the communication closets to serve all offices and laboratories. Flush wall mounted 4-11/16 inches boxes shall be installed 18 inches above finished floor with 3/4-inch conduit risers stubbed above suspended ceiling for voice and data outlets in all the rooms.
2. For new facilities, the RDP shall design, as a minimum, one (1) 4-foot by 8-foot backboard in communications closets on each floor with interconnecting raceways, and raceways in corridors from the communication closets to serve all offices and laboratories. Flush wall mounted 4-11/16 inches boxes shall be installed 18 inches above finished floor with 3/4-inch conduit risers stubbed above suspended ceiling for voice and data outlets in all the rooms.
3. For new facilities, the RDP shall design interconnecting underground raceway(s) from the building to the LBNL telephone duct bank/manhole for connection to LBNL system via telephone and Ethernet cables. Provision shall be made for [__] pair[s] telephone cable[s], and [__] fiber for Ethernet cable.
4. LBNL will provide raceway sizes for the voice and data cables during Preliminary Design phase.
5. Use #6 AWG, minimum, copper conductor for communications service grounding conductor to building structure, nearest ground grid, or suitable grounded structure. Leave 10 feet (3 m) of slack conductor at terminal board or cabinet.

O. Specifications

LBNL will provide technical Master Specification sections for incorporation into the construction documents. The RDP shall review the specification sections, edit them to suit the project, and submit a “track changes” copy to LBNL for review and approval of edits. The edited specification sections shall not be incorporated into the construction documents without LBNL approval.

Division 26	Electrical
Division 27	Communications
Division 28	Electronics Safety and Security

13. NON-STRUCTURAL BUILDING ELEMENTS

Falling hazards from non-structural building elements including equipment, fixtures, ceilings, furniture, and other contents shall be abated, to the extent practical. This includes the following guidelines:

A. All non-structural components and equipment shall be designed to the requirements of "Lateral Force Design Criteria," RD3.22, of the LBNL CDDG, Volume 4 - RDs, unless otherwise specified.
B. Shelves shall have doors, or restraints to keep items from falling. For bookshelves, the restraint shall extend at least one-half inch above the shelf. For chemicals and in other laboratory areas, the restraint shall extend at least 1-1/2 inches above the shelf. Where glass chemical containers shall be stored, the restraint material shall be of a nonmetallic or a rubber coated metallic material.
C. Sliding or swinging cabinet doors shall have mechanical latches.
D. Compressed gas cylinders shall be restrained using approved brackets (LBNL Standard) or with two (2) metal straps or chains that have been firmly attached to walls. When using chains, one (1) shall be located approximately 8 inches above finished floor and the second shall be located approximately 34 inches above finished floor.
E. Flexible utility connections shall be used for fume hoods and other free-standing equipment subject to motion in a seismic event.
F. Where new elements are to be supported by an existing structure and cause an increase in the applied load on the structure by more than 5 percent, the Structural Engineer of Record (SER) shall check the structure to verify if it has the capacity to support the weight of the new elements and any existing loads that shall remain. The structure underneath the path that the element shall travel to its final location shall be likewise checked where applicable. If the existing structure does not have sufficient capacity to support the weight of the new elements then the structure shall be strengthened, supplemented, replaced, or otherwise altered as needed to carry the increased weight. Both the check of the existing structure and any alterations shall conform to the requirements of the building code currently in effect.
G. If new non-structural elements increase the seismic force on any lateral force resisting element by more than 10 percent, the SER shall check the lateral force resisting element and all structural elements that laterally support it as specified in CBC Section 3404.5. If the check determines that the existing structure is insufficient then the structure shall be retrofitted as needed to carry the increased lateral force.

14. SUSTAINABILITY REQUIREMENTS

A. Overview

LBNL follows a policy on Sustainability Standards for New Construction, available in the Laboratory Requirements and Policies Manual. This policy includes responsibilities and policy statements in several areas:

- Policy Statement 1: Living laboratory
- Policy Statement 2: Energy Efficiency – Whole Building Performance Targets
- Policy Statement 3: Energy Efficiency - Code Compliance*
- Policy Statement 4: Energy Efficiency – Mechanical Systems*
- Policy Statement 5: Energy Efficiency – Lighting Systems*
- Policy Statement 6: Renewables
- Policy Statement 7: Green Building*
- Policy Statement 8: Waste Minimization and Diversion
- Policy Statement 9: Water
- Policy Statement 10: Transportation
- Policy Statement 11: Metering*
- Policy Statement 12: Metrics
- Policy Statement 13: Reporting
- Policy Statement 14: Large Procurements
- Policy Statement 15: Peer Reviews

For remodeling projects in existing buildings, Policy Statements 3, 4, 5, 7, and 11 (marked by asterisks above) shall also apply to the extent those associated systems are replaced. Project teams shall confirm the limits of construction and applicable policy statements with the University's Representative.

Note that metering requirements are provided in the Sustainability Standards for New Construction that apply to both new construction and remodeling projects and supplement the metering requirements provided in Section 11.10, Electrical Meter Requirements for Electricity Recharges.

The RDP shall submit documentation sufficient to confirm compliance with the Sustainability Standards for New Construction and policy statements applicable to remodeling projects. Code compliance documentation, stamped by a licensed engineer, shall be included in the 100% Final Design submittal.

B. Required energy conservation measures

This sub-section identifies energy conservation measures that are required.

1. Building Envelope and Orientation

    a. Use appropriate glazing systems to minimize heat loss and reflected glare to adjacent buildings or public areas.
    b. The use of projections and roof overhangs is recommended over windows in sunny locations (especially south and west orientations). The length of the projection shall be calculated to provide solar gain in winter and shading in the summer. Horizontal shutters, fixed awnings, self-shading window designs or other architectural devices, may also provide this function. If exterior shading is not complete, windows shall be equipped with lose-fitting insulating drapes, shades or blinds.

c. Unless passive solar heating is the goal and direct beam solar input creates no problems for occupants, the standards for glazing are:
Maximum Solar Heat Gain Coefficient (SHGC): 0.27
Maximum U-Value Winter: 0.28
Maximum U-value Summer: 0.26
Maximum Visible Light Transmittance (VLT): 64%
Minimum Light to Solar Gain (LSG) ratio: 2.37
d. Orient the building along an east-west axis to optimize passive low-energy design strategies.

2. Parallel Staged Devices

a. Pumps and cooling towers shall be parallel staged devices (i.e., use two 50% lead/lag pumps with VFDs instead of one 100% pump). Parallel staged devices shall be lead/lag alternated when more than one is off or more than one is on so that the device with the most operating hours is made the later stage device and the one with the least number of hours is made the earlier stage device.

3. Hydronic Systems

a. For pumping systems that are 3/4 HP and larger, provide variable water volume pumping systems with frequency drive (VFD) control for chilled water, hot water, heat recovery and possibly other types of water systems. Chilled water systems using chillers shall be separated into a primary-secondary system so that the chillers may operate at constant volume.
b. For heating hot water systems, use 180-degree hot water supply temperature for coil sizing. Hot water system delta T shall be maximized to reduce pump and pipe sizing. Typically, a 40 to 60 degree delta T shall be used for air handling coils and a 30 to 40 degree delta T shall be used for reheat coils when 180-degree hot water system is used.
c. For hydronic systems where variable water volume (VWV) is used, provide the following:

(1) Install modulating 2-way valves with tight shut-off rated to close against a differential pressure of 1-1/2 times pump head.
(2) Provide no more than one (1) 3-way valve (or end-of-line needle valves) on heating hot water systems.
(3) Locate differential pressure sensor at hydraulically most remote coil.
(4) If hydraulically most remote coil is variable, provide multiple differential pressure sensors and use a low signal selector to send proper signal to variable frequency drive.
(5) Limit total bypass gpm through 3-way valves to 1.5 gpm per pump horsepower by installing balance valve in the bypass of all 3-way valves.

d. For constant or variable flow water systems, provide 2- way control valves for all reheat and recool coils except as noted above.
e. In coil schedule, identify the control valve Cv value.
f. Flow sensors, integrated to the building management system, shall be provided on all return headers.

4. Air Handlers

a. Provide a variable frequency drive (VFD) for VAV systems with motors 1.0 HP and larger.
b. Provide a variable frequency drive (VFD) for constant volume systems with motors 1.0 HP and larger.

c. Chilled water, hot water, direct expansion, heat recovery, terminal and other coils shall be sized at a life cycle cost effective face velocity and pressure drop. Maximum desired face velocities and air pressure drops are identified below:

System Type Operating		Desired Max.	Max. Coil Wet Air Pressure			
	Hours	Coil Face Velocity Drop (H2O)				
		(fpm)	CHW	Run-	Hot Water	
			& DX	around	110F	180F
Constant	24h/d, 7d/w	350	0.45	0.40	0.30	0.10
Constant	10h/d, 5d/w	400	0.50	0.45	0.35	0.13
Variable	24h/d, 7d/w	400	0.50	0.45	0.35	0.13
Variable	10h/d, 5d/w	450	0.55	0.50	0.40	0.16

d. For rooms that are provided with dedicated air handlers (e.g., large meeting rooms, auditoriums, etc.), provide occupancy sensor control of lighting systems and air handlers. For small air handlers, cycle fan to maintain thermostat setpoint when no occupancy is sensed. For larger air handlers, set fan to low speed (approximately 20 Hz) when no motion is sensed.

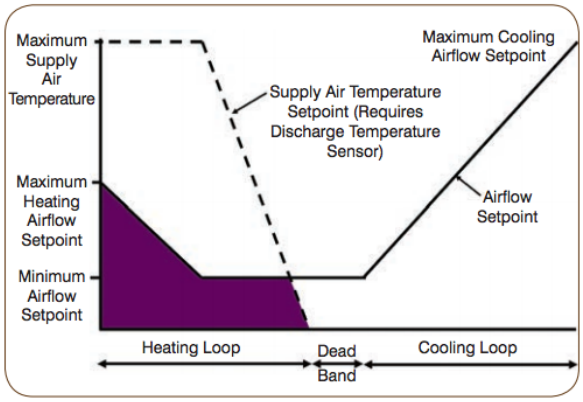
e. For intermittently occupied spaces that are equipped with dedicated air handlers or terminal units (e.g., meeting rooms, auditoriums), provide ASHRAE 62-1989 approved demand ventilation control (DCV) of outside air dampers. If CO2 sensors are used, then modulate OSA dampers to maintain 600 to 700 ppm of CO2 during occupied periods. The minimum OSA rate shall be 0.15 cfm/person during occupied periods. The maximum OSA rate shall be 100 percent.

f. For air handlers approximately 7.5 HP and larger, provide low pressure drop, UL-approved air filters similar to the following:

Filter Efficiency	Similar to	Desired Maximum Face Velocity (FPM) (H_2O)	Maximum Initial Pressure Drop
35 %	LUWA FP75	400	0.17
65 %	LUWA FP75	400	0.17
85 %	LUWA FP85	400	0.19
95 %	LUWA FP95	375	0.23
99.97 % HEPA	FARR	250	0.65
99.99 % HEPA	FARR	200	0.65

5. VAV Boxes

a. Provide dual maximum control logic. Provide the following design airflow rates on the mechanical schedules: maximum cooling airflow, maximum heating airflow, and minimum airflow.



b. The maximum cooling airflow shall be the airflow required at the minimum supply air temperature to meet the maximum calculated cooling load.
c. The maximum heating airflow shall be the maximum of: 30% of the maximum cooling airflow, 0.15 cfm/sf, 15 cfm/person, the controllable minimum for the specifically selected VAV box, or the minimum airflow required to satisfy the envelope heating load only (i.e., do not include internal loads) at the maximum supply air temperature.
d. The minimum airflow shall be the maximum of: 0.15 cfm/sf, 15 cfm/person, and the controllable minimum for the specifically selected VAV box, per Manufacturer's datasheets.
e. The maximum air pressure drop (PD) across a terminal box shall be 0.6 inches.

6. Ductwork

a. SMACNA smoke and bubble tests indicate that splitters, extractors, scoops and 90 degree branch taps have high pressure drops and shall be avoided. Smoke tests also indicate that the fittings in the following table have low pressure drops and are the fittings of choice for SA, RA and EA branch ducts. Please show or require these fittings in specs.

PREFERRED BRANCH TAKE-OFFS

Duct Branch	Preferred	SMACNA Figure*
Rectangular to Rectangular	Shoe	14-14.N or W
Rectangular to Round	Conical	14-14.M or V
Round to Round	Wye	14-14.B, C or J

* from SMACNA HVAC Systems Duct Design (1990).

b. Require random (or complete) duct leakage testing in all ducts rated at (1 or) 2 inches of water and greater.

7. Heat Recovery And Indirect Evaporative Cooling

a. Heat recovery and/or indirect evaporative cooling systems shall be provided for all 100 percent outside air systems and shall be evaluated for systems using high outside air flow rates.

8. Compressed Air And Vacuum Pump Systems

    a. Lead/lag systems are desired for systems requiring 10 HP compressors/pumps and larger (i.e., split one (1) 10 HP compressor/pump into two (2) 5 HP or two (2) 7.5 HP lead/lag compressor/pumps).
    b. Provide intercooled and aftercooled, 2 stage compressors/ pumps for all systems 5 HP and larger.
    c. Heat rejection to the HVAC system shall be avoided. Heat rejection directly to outside is preferred for high-grade sources of heat such as air compressors. Heat shall not be rejected into main chilled water systems or into once through water cooling systems. Heat recovery into DHW or runaround systems may be considered.
    d. Do not provide once through cooling water systems.

9. Mechanical

    a. All motors 1 HP and over that are used at least 1,000 hours per year shall be premium efficiency per requirements of NEMA MG 1-2014.
    b. Fractional horsepower motors 1/20 HP and larger are not to be shaded pole motors.
    c. For variable frequency drives (VFDs) provide adequate protection from current harmonic distortion, typically a 3 percent input line filter or isolation transformer.

15. BUILDING AND DIRECTIONAL SIGNAGE REQUIREMENTS

A. Overview

LBNL has a signage standard that is maintained by the Facilities Planning Department. Refer to the “Berkeley Lab Signage and Public Information Standards Manual” on the Facilities website (http://facilities.lbl.gov/).

B. Intentions

The intent of the guidelines is to:

1. Provide graphic standards for a LBNL sign program;
2. Provide category classification for all sign types in the program;
3. Assist in identifying which sign type is appropriate to use;
4. Help in developing sign packages for specific areas or facilities; and
5. Assist in the application and placement of signs.

The sign program provides for consistency of message, appearance, and identity by the use of shape, size, color, typeface, symbols and wording. Careful implementation of these guidelines shall insure a consistent and highly recognizable visual identity for the LBNL site. This sign program strives to ensure a smooth flow of pedestrian and vehicular traffic in and around buildings. It also insures continuity of identification and information for emergency response and way finding.

C. Laboratory room signage

Laboratory faucets served by industrial water shall be labeled “Industrial Water – Do Not Drink”. Signs to be of panel type construction with dimensions of 1-inch by 4-inch minimum. Panel color shall be dark with lettering of high contrast. Coordinate with LBNL sign program.

D. Emergency evacuation sign

All buildings over one (1) story high shall have building evacuation signs posted on every floor. The signs shall be posted at all stairway and elevator landings and immediately inside all public entrances to the building (California Code of Regulations, Title 19). The evacuation plan sign is noted in the LBNL Sign Standard.

The insert for the holder shall conform to the following criteria to comply with state regulations:

1. Show floor plan for the level on which it is placed. Shall be easy to see immediately by someone entering that floor of the building.
2. Place signs no more than 4 feet above finished floor.
3. Make sign’s lettering at least 3/16 inch high in a sans-serif font. The words shall be in sharp contrast to the background and easy to read.
4. Include emergency procedure information for the physically disabled.
5. Indicate the locations of exits and fire alarm pull stations.
6. Describe what the fire alarm sounds and looks like (audible and visual warning devices).
7. List the Fire Marshal’s Office emergency telephone number.
8. If there are elevators on the floor, state they are not to be used during emergencies.
9. Other pertinent information may be added to the sign, such as location of fire extinguishers, hazardous material spill kits or emergency preparedness equipment.